To: Koutrakis, Petros[petros@hsph.harvard.edu]; Bell, Michelle[michelle.bell@yale.edu]; Julian Marshall (jdmarsh@uw.edu)[jdmarsh@uw.edu]
Sent: Thur 1/26/2017 6:09:29 PM
Subject: RE: ACE Center Directors Call -- Draft notes from previous call, PLEASE REVIEW

H

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, January 25, 2017 5:39 PM
To: Callan, Richard <Callan.Richard@epa.gov>; Bell, Michelle <michelle.bell@yale.edu>; Julian Marshall (jdmarsh@uw.edu) <jdmarsh@uw.edu>
Subject: RE: ACE Center Directors Call -- Draft notes from previous call, PLEASE REVIEW

Hi Richard I am ok with this

Gina McCarthy will be teaching at Harvard and she will have a job. So we should be able to bring her

From: Callan, Richard [mailto:Callan.Richard@epa.gov]
Sent: Wednesday, January 25, 2017 4:57 PM
To: Bell, Michelle <michelle.bell@yale.edu>; Koutrakis, Petros <petros@hsph.harvard.edu>; Julian Marshall (jdmarsh@uw.edu) <jdmarsh@uw.edu>
Subject: FW: ACE Center Directors Call -- Draft notes from previous call, PLEASE REVIEW

Hi Michelle, Petros and Julian,

I hope you are all well. I put together some draft notes from the last ACE Centers Directors call and would like to send them out to the larger group but wanted to give you a chance to review first. Please let me know by 11:00 a.m. tomorrow (Thursday 1/26) if you have any edits. Hopefully they look OK to you.

Best regards,

Rich

Rich Callan, MPH | US Environmental Protection Agency | National Center for Environmental Research

Applied Science and Education Division

Mailing Address: 1200 Pennsylvania Ave., NW, Mail Code 8725R, Washington, DC 20460-0001

Express Mail Address: 1300 Pennsylvania Ave., NW, RRB Mezzanine M312C, Washington, DC 20004

Phone: 202.564.4191 (office) | callan.richard@epa.gov

From: Hunt, Sherri
Sent: Thursday, September 22, 2016 10:52 AM
To: Hunt, Sherri; Katz, Taylor; Vette, Alan; Miller, Andy; Hassett-Sipple, Beth; Bell, Michelle; Roger Peng; Petros Koutrakis; bcoull@hsph.harvard.edu; Allen Robinson; Julian Marshall; Katherine Tucker; Alice Smythe; Jones, Diana; Ilacqua, Vito; Callan, Richard; Costa, Dan
Cc: Baxter, Lisa; Grambsch, Anne; Hagler, Gayle; Nunez, Carlos
Subject: ACE Center Directors Call
When: Thursday, January 26, 2017 2:00 PM-3:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: 1.866.299.3188, code: 2025644486#

Hi All,

Now that we've had our official Kickoff for the ACE Centers, I'd like to start having regular Center Directors calls. When I asked several weeks ago, it looked like this time should work for everyone.

The **goals** of these calls are to discuss Center coordination, research updates, annual meeting planning, SAC meetings and feedback, and to help us stay connected as a team. The **participants** will include Center directors and co-directors, STAR project offices, and some interested ACE scientists. While I'm including your administrative support in the invitation, they typically will not need to attend.

If we don't need one we'll cancel, but I'm putting them on the calendar monthly.

If you have agenda items that you'd like to discuss as a group, please let me know.

Regards,

Sherri

To: Bell, Michelle[michelle.bell@yale.edu]; Jones, Diana[diana.jones@yale.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]
Cc: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Keating, Terry[Keating.Terry@epa.gov]; Costa, Dan[Costa.Dan@epa.gov]
From: Hunt, Sherri
Sent: Fri 5/5/2017 4:28:14 PM
Subject: ACE Centers Meeting, agenda suggestions
Agenda-ACE Annual Meeting 2017_suggestion.docx

Hi All,

Based on the discussion at our last directors call, I've developed the attached revised the meeting agenda. Please provide feedback to the items below and anything else to me as soon as possible. Let's make a hard deadline of next Friday, May 12.

A couple of items are worth specific note:

(in no particular order, some logistical and some content)

1. I kept Center presentation times at 60 minutes, but allocated a shorter time for EPA updates. Is everyone ok with this?

2. I decided to give the Harvard Center the acronym RAPM (pronounced rap-em). This can be rejected without consequences.

3. Do we want to include speaker names on the agenda? I expect each Center may have multiple speakers. I'm happy to do whatever, but suggest consistency so if we are including names, I need to know what they are.

4. The Collaborative Project Brainstorming/Discussion groups are simply suggestions. I think it makes sense to have people from the Centers lead these since most successful projects have a champion working on them. If we are going to do this, I need your feedback on the topics and the leaders. NCER and EPA will be happy to participate in the discussion and support with notetaking.

5. I kept the hour between the poster session and reception, but is it needed?

6. Are we already committed to a start time for the reception on June 1?

7. On June 2, I likely need corrections to the speakers for the morning talks. Also, is this a good grouping? Any changes to suggest?

8. June 2 also includes a block of time which could be for more collaborative discussions or for meetings within each Center (since two of them are geographically dispersed). Which do you prefer?

9. We should identify a closing discussion leader and some key questions on points to be made. Suggestions?

Thanks a bunch.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

Air Climate Energy (ACE) Centers Meeting
Hosted by Harvard/MIT ACE Center
June 1 – 2, 2017
Le Meridien Hotel, 20 Sidney Street, Cambridge, MA

Thursday June 1, 2017		
8:30 AM	9:00 AM	Breakfast
9:00 AM	9:15 AM	Welcome: Petros Koutrakis, Dan Costa
9:15 AM	10:15 AM	CASES: Center for Air, Climate, and Energy Solutions
10:15 AM	10:45 AM	**Break**
10:45 AM	11:45 AM	SEARCH: Solutions to Energy, AiR, Climate and Health
11:45 AM	12:30 PM	EPA Related Activities: Regional Perspective, Life-cycle Analysis, Including Social Science
12:30 PM	2:00 PM	**Lunch**
2:00 PM	3:00 PM	RAPM: Regional Air Pollution Mixtures: The past and future impacts of emissions controls and climate change on air quality and health, Harvard
3:00 PM	3:45 PM	Collaborative Project Brainstorming, Possible groups: 1) Epidemiology of Long-term effects, 2) Sensors, 3) Energy Modeling, 4) Methods for estimating exposure
3:45 PM	4:15 PM	**Break**
4:15 PM	5:45 PM	Poster Session (max size 3' by 4', portrait or landscape)
5:45 PM	6:45 PM	Transportation
6:45 PM	8:45 PM	Reception
8:45 PM		**Adjourn for the Day**
Friday June 2, 2017		
8:30 AM	9:00 AM	Breakfast
9:00 AM	9:30 AM	Insights on EJ Metrics: Julien Marshall
9:30 AM	10:00 AM	Insights from Policy Core: Michelle Bell
10:00 AM	10:30 AM	Insights on Reduced Form Models: Julien Marshall
10:30 AM	11:00 AM	**Break**
11:00 AM	12:00 PM	Collaborative Project Brainstorming or Individual Center Time
12:00 PM	1:00 PM	Discussion, Collaborative Directions, What's Next?, and Closing Thoughts
1:00 PM		**Adjourn**

To: Bell, Michelle[michelle.bell@yale.edu]; Jones, Diana[diana.jones@yale.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]
Cc: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Keating, Terry[Keating.Terry@epa.gov]; Costa, Dan[Costa.Dan@epa.gov]
From: Hunt, Sherri
Sent: Thur 5/11/2017 7:14:16 PM
Subject: RE: ACE Centers Meeting, agenda suggestions
Agenda-ACE Annual Meeting 2017_suggestion.docx

Hi All,

This is a reminder to have a look at the agenda. So far the only feedback I've received has been from Alice regarding logistics. Lots of EPA people are asking about this.

I'd especially like to know if Julien and Michelle are okay with the additional topics that I assigned to them.

Thanks for your quick response!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Hunt, Sherri

Sent: Friday, May 05, 2017 12:28 PM
To: 'Bell, Michelle' <michelle.bell@yale.edu>; 'Jones, Diana' <diana.jones@yale.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; 'Julian Marshall' <jdmarsh@uw.edu>; 'Katherine Tucker' <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <ilacqua.vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <costa.dan@epa.gov>
Subject: ACE Centers Meeting, agenda suggestions

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Thanks a bunch.

Regards,

Sherri

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DRAFT AGENDA

June 1 – 2, 2016
Air Climate Energy (ACE) Centers Meeting
Hosted by Harvard/MIT ACE Center
Le Meridien Hotel, 20 Sidney Street, Cambridge, MA

Day 1 - June 1

8:30– 9:00 AM	Breakfast
9:00 – 9:15	Introductions by Dan Costa? and Sherri Hunt. Announcements by Petros Koutrakis
9:15 – 10:00	How ACE research can help communities to address current and future environmental challenges (Invited Speaker)
10:00 – 11:00	Center A Presentations and Discussion
11:00 – 11:30	Coffee Break
11:30 – 12:30	Center B Presentations and Discussion
12:30 – 1:30 PM	Lunch (meeting attendees have lunch on their own in local area or hotel restaurant)
1:30 – 2:30	Center C Presentations and Discussion
2:30 – 3:00	HEI or else
3:00 – 3:30	Coffee Break
3:30 – 5:00	Poster Sessions (on general research)
6:00 – 8:30	Reception/Dinner Le Meridian Hotel Roof garden

Day 2 – June 2

8:30 – 9:00 AM	Breakfast
9:00 – 10:00	Gina McCarthy (to be former EPA administrator)
10:00 – 11:00	An exciting scientific topic that is relevant to ACE research (invited speaker from the Boston area)
11:00 – 11:30	Coffee break/room set-up
11:30 – 12:30	EPA research presentation and discussion
12:00 PM	Closing Remarks from Petros and Dan
	Adjourn

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Katz, Taylor[Katz.Taylor@epa.gov]; Costa, Dan[Costa.Dan@epa.gov]; Vette, Alan[Vette.Alan@epa.gov]; Miller, Andy[Miller.Andy@epa.gov]; Hassett-Sipple, Beth[Hassett-Sipple.Beth@epa.gov]; Bell, Michelle[michelle.bell@yale.edu]; Roger Peng[rdpeng@jhu.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Jones, Diana[diana.jones@yale.edu]; Hunt, Sherri[Hunt.Sherri@epa.gov]
Cc: Baxter, Lisa[Baxter.Lisa@epa.gov]; Grambsch, Anne[Grambsch.Anne@epa.gov]; Hagler, Gayle[Hagler.Gayle@epa.gov]; Nunez, Carlos[Nunez.Carlos@epa.gov]
From: Hunt, Sherri
Sent: Fri 12/2/2016 4:07:44 PM
Subject: ACE Center Directors Call

Hi All,

Thanks for joining us yesterday. As discussed, at our next call Petros will bring a draft agenda for the June 1-2 meeting and everyone will be thinking of speakers we may want to invite or ways to encourage useful discussion among scientists within the Centers and EPA. I would also like to share research progress updates at that time as well.

I incorrectly noted the time for our next call – we are currently scheduled at talk at 2 pm on the 4th Thursday of the month, i.e. Jan. 26, Feb 23, March 23, April 27..

I hope that everyone has a fun and restful holiday

All the best,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

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To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Katz, Taylor[Katz.Taylor@epa.gov]; Costa, Dan[Costa.Dan@epa.gov]; Vette, Alan[Vette.Alan@epa.gov]; Miller, Andy[Miller.Andy@epa.gov]; Hassett-Sipple, Beth[Hassett-Sipple.Beth@epa.gov]; Bell, Michelle[michelle.bell@yale.edu]; Roger Peng[rdpeng@jhu.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Jones, Diana[diana.jones@yale.edu]
Cc: Baxter, Lisa[Baxter.Lisa@epa.gov]; Grambsch, Anne[Grambsch.Anne@epa.gov]; Hagler, Gayle[Hagler.Gayle@epa.gov]; Nunez, Carlos[Nunez.Carlos@epa.gov]
From: Hunt, Sherri
Sent: Mon 6/19/2017 5:23:31 PM
Subject: ACE Center Directors Call

Hi All,

I am unable to attend an ACE Center Directors call this Thursday due to parenting responsibilities. However, I would like to have a discussion to follow-up on items discussed at our recent meeting and other coordination and collaborations. I'm deleting this calendar entry, but Rich Callan will be polling the group and scheduling a new meeting time. Rich will be taking over the coordination of these calls.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

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To: Koutrakis, Petros[petros@hsph.harvard.edu]; Brent Coull[bacoull@gmail.com]
From: Hunt, Sherri
Sent: Tue 5/30/2017 1:14:14 PM
Subject: RE: ACE Center Directors Call

Hi Petros,

I understand this is a challenging situation. I've spent more time thinking about this and also reviewed the Centers T&C.

The T&C for your award states that each Center will host one annual Centers meeting. While I'm happy to plan times for discussion and to participate in the development of the meeting agenda, it's problematic for me (or others in my office) to contribute to discussions regarding the financial aspects of the meeting because this gives the appears that EPA is directing a grantee in how funds are spent. Consequently, it would be best for you to resolve this issue without my involvement.

On a related note, several months ago I informed EPA meeting employees that they should expect to pay a fee to cover meals if they want to participate in the group meals and breaks. NCER management has determined that calling this a registration fee (as we did in the past) is no longer acceptable. However, I don't recall whether this issue was ever discussed on a directors' call and I haven't been able to find anything regarding this in my notes. Since formally, the T&C don't specify it means to "host," this is something that you should clarify with the other Centers. If this has not been discussed, then I would anticipate that the other Centers are not expecting to pay a fee. (My personal feeling during the CLARCs was that this ended up being a lot of work to pass funds between institutions for a result that probably did not change the balance at the end of the projects.)

Finally, the goal of these meetings is to improve the connections and collaborations across Centers. This is important as it has been one of the strong points for justifying the importance and value of the Centers program. From this perspective, you should consider the other Center investigators in the same way that you would any scientific visitor to Harvard.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Friday, May 26, 2017 1:10 PM
To: Brent Coull <bacoull@gmail.com>; Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Center Directors Call

Sheri I had to be forceful today because I do not want us to pay for the mistakes of others

Have a nice weekend

petros

From: Brent Coull [mailto:bacoull@gmail.com]
Sent: Friday, May 26, 2017 7:52 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Re: ACE Center Directors Call

Hi Sherri, I am happy to lead the discussion. Unfortunately I cannot make the call today but I'd love to hear your thoughts on what'd you'd like for that session. Would you like a report back from certain sessions? A summary of certain themes from the two days? Or should I serve more as a moderator for open discussion from the entire group?

Thanks

Brent

On May 26, 2017, at 7:38 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Let's discuss the final agenda and smaller group times.

Call Agenda for 5/26/17:

Logistics (Alice & Petros)

Meeting agenda (latest draft is attached):

finalize:

•□□□□□□□□ Group discussion leaders (Schwartz not yet confirmed),

•□□□□□□□□ final discussion (Coull not yet confirmed),

•□□□□□□□□ anything else?

Apologies for the late reschedule.

<mime-attachment.ics>

<Agenda-ACE Annual Meeting 20170523.docx>

Air Climate Energy (ACE) Centers Meeting
Hosted by Harvard/MIT ACE Center
June 1 – 2, 2017
Le Meridien Hotel, 20 Sidney Street, Cambridge, MA

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9:15 AM	10:15 AM	CASES: Center for Air, Climate, and Energy Solutions
10:15 AM	10:45 AM	**Break**
10:45 AM	11:45 AM	SEARCH: Solutions to Energy, AiR, Climate and Health
11:45 AM	12:30 PM	EPA Related Activities: Life Cycle Assessment for Regionalization and Inventory Generation: Michael Gonzalez Including Social Science in Air Pollution Research: Lisa Baxter Perspective on needs within EPA Regions: Bob Judge
12:30 PM	2:00 PM	**Lunch**
2:00 PM	3:00 PM	RAPM: Regional Air Pollution Mixtures: The past and future impacts of emissions controls and climate change on air quality and health, Harvard
3:00 PM	4:00 PM	**Collaborative Project Brainstorming** or **Data and Model Sharing** Optional groups: 1) Epidemiology of Long-term effects: Joel Schwartz 2) Sensors: Kirsten Koehler 3) Modeling tools and applications: Chris Tessum and Noelle Selin 4) Policy/stakeholder interaction: Julian Marshall 5) Others?
4:00 PM	4:30 PM	**Break**
4:30 PM	6:30 PM	Poster Session (max size 3' by 4', portrait or landscape)
6:30 PM	8:30 PM	Reception
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Friday June 2, 2017		
8:30 AM	9:00 AM	Breakfast
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To: Petros Koutrakis[Petros@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Costa, Dan[Costa.Dan@epa.gov]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Bell, Michelle[michelle.bell@yale.edu]; Gonzalez, Michael[Gonzalez.Michael@epa.gov]; Baxter, Lisa[Baxter.Lisa@epa.gov]; Judge, Robert[Judge.Robert@epa.gov]; jschwrtz@hsph.harvard.edu[jschwrtz@hsph.harvard.edu]; kkoehle1@jhu.edu[kkoehle1@jhu.edu]; Christopher Tessum[ctessum@uw.edu]; selin@mit.edu[selin@mit.edu]; Peter Adams[peteradams@cmu.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]
Cc: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]
From: Hunt, Sherri
Sent: Tue 5/23/2017 9:00:59 PM
Subject: ACE Centers Annual Meeting role - PLEASE CONFIRM
Agenda-ACE Annual Meeting 20170523.docx

Hi All,

If you are getting this email, it means that you are on the agenda as either a presenter or a discussion leader. Please check the agenda and confirm that you will fill this role.

(Note some of you have been recommended and this might be the first you are hearing about it. Apologies!)

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

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To: Bell, Michelle[michelle.bell@yale.edu]
Cc: Jones, Diana[diana.jones@yale.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Keating, Terry[Keating.Terry@epa.gov]; Costa, Dan[Costa.Dan@epa.gov]
From: Hunt, Sherri
Sent: Fri 5/12/2017 11:53:32 AM
Subject: Re: ACE Centers Meeting, agenda suggestions

Thanks!

Regards,
Sherri Hunt
571.339.9491

Sent from my iPhone

On May 11, 2017, at 6:25 PM, Bell, Michelle <michelle.bell@yale.edu> wrote:

I am fine with the additional topic. Thanks.

Michelle

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, May 11, 2017 3:14 PM
To: Bell, Michelle; Jones, Diana; Petros Koutrakis; Alice Smythe; Allen Robinson; Julian Marshall; Katherine Tucker
Cc: Ilacqua, Vito; Callan, Richard; Keating, Terry; Costa, Dan
Subject: RE: ACE Centers Meeting, agenda suggestions

Hi All,

This is a reminder to have a look at the agenda. So far the only feedback I've received has been from Alice regarding logistics. Lots of EPA people are asking about this.

I'd especially like to know if Julien and Michelle are okay with the additional topics that I assigned to them.

Thanks for your quick response!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Hunt, Sherri
Sent: Friday, May 05, 2017 12:28 PM
To: 'Bell, Michelle' <michelle.bell@yale.edu>; 'Jones, Diana' <diana.jones@yale.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; 'Julian Marshall' <jdmarsh@uw.edu>; 'Katherine Tucker' <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <ilacqua.vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <costa.dan@epa.gov>
Subject: ACE Centers Meeting, agenda suggestions

Hi All,

Based on the discussion at our last directors call, I've developed the attached revised the meeting agenda. Please provide feedback to the items below and anything else to me as soon as possible. Let's make a hard deadline of next Friday, May 12.

A couple of items are worth specific note:

(in no particular order, some logistical and some content)

1. I kept Center presentation times at 60 minutes, but allocated a shorter time for EPA updates. Is everyone ok with this?

2. I decided to give the Harvard Center the acronym RAPM (pronounced rap-em). This can be rejected without consequences.

3. Do we want to include speaker names on the agenda? I expect each Center may have multiple speakers. I'm happy to do whatever, but suggest consistency so if we are including names, I need to know what they are.

4. The Collaborative Project Brainstorming/Discussion groups are simply suggestions. I think it makes sense to have people from the Centers lead these since most successful projects have a champion working on them. If we are going to do this, I need your feedback on the topics and the leaders. NCER and EPA will be happy to participate in the discussion and support with notetaking.

5. I kept the hour between the poster session and reception, but is it needed?

6. Are we already committed to a start time for the reception on June 1?

7. On June 2, I likely need corrections to the speakers for the morning talks. Also, is this a good grouping? Any changes to suggest?

8. June 2 also includes a block of time which could be for more collaborative discussions or for meetings within each Center (since two of them are geographically dispersed). Which do you prefer?

9. We should identify a closing discussion leader and some key questions on points to be made. Suggestions?

Thanks a bunch.

Regards,

Sherri

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To: Petros Koutrakis[Petros@hsph.harvard.edu]; Bell, Michelle[michelle.bell@yale.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Jones, Diana[diana.jones@yale.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Baxter, Lisa[Baxter.Lisa@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Roger Peng[rdpeng@jhu.edu]
From: Hunt, Sherri
Sent: Thur 4/27/2017 6:05:27 PM
Subject: FW: ACE Centers Annual Meeting
DRAFT Agenda-ACE Annual Meeting 2017.docx

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

DRAFT AGENDA

June 1 – 2, 2017
Air Climate Energy (ACE) Centers Meeting
Hosted by Harvard/MIT ACE Center
Le Meridien Hotel, 20 Sidney Street, Cambridge, MA

Day 1 - June 1

8:30– 9:00 AM	Breakfast
9:00 – 9:15	Introductions by Dan Costa? and Sherri Hunt. Announcements by Petros Koutrakis
9:15 – 10:00	How ACE research can help communities to address current and future environmental challenges (Invite Paul Miller??))
10:00 – 11:00	Center A Presentations and Discussion
11:00 – 11:30	Coffee Break
11:30 – 12:30	Center B Presentations and Discussion
12:30 – 1:30 PM	Lunch (meeting attendees have lunch on their own in local area or hotel restaurant)
1:30 – 2:30	Center C Presentations and Discussion
2:30 – 3:00	HEI or else
3:00 – 3:30	Coffee Break
3:30 – 5:00	Poster Sessions (on general research – 6 posters from each center + EPA)
6:00 – 8:30	Reception/Dinner Le Meridian Hotel Roof garden

Day 2 – June 2

8:30 – 9:00 AM	Breakfast
9:00 – 10:00	Ideas for collaborations
10:00 – 11:00	EPA research presentation and discussion
11:00 – 11:30	Coffee break/room set-up
11:30 – 12:30	Discussions
12:3012:45	Closing Remarks from Petros and Dan
	Adjourn

ACE Directors Call #1 DRAFT Notes – 10/27/2016

Attendees: Michelle Bell (Yale), Petros Koutrakis (Harvard/MIT), Julian Marshall (CMU), Alan Vette (EPA), Vito Ilacqua (EPA), Rich Callan (EPA), Taylor Katz (EPA)

Agenda and Discussion

1. Work across Centers in webinars – do you want to do this?

   Discussion: Seems too early on right now. Need to explore this further.

2. How can we help you develop cross-Center projects?

   Discussion: Seems too early on right now. Cross-pollination of ideas has already started. Would be good for us to consider collective experience from other collaborations, what might be of help to encourage these?

3. SAC meeting scheduling – how's it going?

   Michelle (Yale): First SAC meeting scheduled for March 23rd-24th, 2017 in New Haven, CT.
   Petros (Harvard): Will schedule in next couple of months.
   Marshall (CMU): First SAC meeting scheduled for January 27th, 2017 in Pittsburgh, PA.

   Discussion: Should encourage cross-talk between the Centers. Each SAC has at least one representative from a different Center. Michelle has Francesca Dominici (Harvard) on her SAC, Petros has invited Michelle, and CMU (Allen and Julian) has Noelle Selin (MIT/Harvard Center) and John Weyant (Stanford/Yale Center) on the SAC.

4. **ACE Centers Annual Meeting: June 1st-June 2nd, 2017 at Harvard/MIT ACE Center in Boston.** Alice Smythe of Harvard/MIT ACE Center is coordinating.

   a. Should the Annual Meeting be open to the public?

      Discussion: Harvard is hosting the meeting so discussed that Harvard could decide, but consensus was that for this first meeting that it would be best if it were not open to the public.

   b. Should we invite HEI low-level pollutant PIs to the annual meeting?

      Discussion: It would be better for this first meeting to limit attendance to ACE Center researchers and staff and EPA.

   c. Would we need a registration fee to cover costs? For EPA-organized meetings, we can't charge a registration fee and it limits EPA's ability to communicate about the meeting

      Discussion: Harvard would like to have a $100 per person registration fee to cover food and venue expenses. EPA to check on what can and can't be covered and get back to Petros.

5. Other requests/comments about planning the annual meeting?

   Discussion: For Clean Air Research Center meetings we had a committee to organize, 1 representative from each Center to put together the meeting, each CLARC had time on part of monthly calls. Need to start talking about agenda, format, organization of meeting. In future years, could make Day 1 a Centers-only meeting and Day 2 could be a public meeting

6. Time/day for ongoing monthly (or bimonthly) calls?

   Current time seems OK for now, can revisit. Monthly calls, for now.

Next steps: EPA to find out what could be included in annual meeting registration fee to make it feasible to attend and publicize.

Agenda for next call should be to discuss format for the annual meeting, what kinds of sessions we want to have, so Petros can start working on a draft agenda. Could be a 1-1/2-day meeting to accommodate participants from the West Coast.

Can review Terms and Conditions on next call as well.

Next call:

Thursday, December 1st, 2016, 2:00 p.m. – 3:00 p.m. Eastern Time

Call-in: 1-866-299-3188
Conference Code: 202 564 4486#

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Callan, Richard
Sent: Mon 6/19/2017 7:58:00 PM
Subject: RE: ACE Center Directors Call -- Rescheduling June 2017 Call -- Thank You

Excellent, thank you Alice. Thank you to you and Petros for such a great meeting.

Best regards,

Rich

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, June 19, 2017 3:52 PM
To: Callan, Richard <Callan.Richard@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: ACE Center Directors Call -- Rescheduling June 2017 Call

Hi Rich, June 29 at 2:00 works great with Petros's schedule.

Thank you,

Alice

From: Callan, Richard [mailto:Callan.Richard@epa.gov]
Sent: Monday, June 19, 2017 3:42 PM
To: Bell, Michelle; Roger Peng; Koutrakis, Petros; Coull, Brent; Allen Robinson; Julian Marshall; Katherine Tucker; Smythe, Alice; Jones, Diana; Hunt, Sherri; Ilacqua, Vito; Costa, Dan; Vette, Alan; Miller, Andy; Hassett-Sipple, Beth
Cc: Baxter, Lisa; Grambsch, Anne; Hagler, Gayle; Nunez, Carlos
Subject: RE: ACE Center Directors Call -- Rescheduling June 2017 Call

Hi All,

Let's see if Thursday, June 29th at 2:00 p.m. Eastern would work. As an alternate, we can try for that day at 3:00 p.m. Eastern. Please respond to the Doodle poll to confirm your availability for both times at

https://doodle.com/poll/acsq2dhkkykuivsa.

Best regards,

Rich

From: Hunt, Sherri
Sent: Monday, June 19, 2017 1:24 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Katz, Taylor <Katz.Taylor@epa.gov>; Costa, Dan <Costa.Dan@epa.gov>; Vette, Alan <Vette.Alan@epa.gov>; Miller, Andy <Miller.Andy@epa.gov>; Hassett-Sipple, Beth <Hassett-Sipple.Beth@epa.gov>; Bell, Michelle <michelle.bell@yale.edu>; Roger Peng <rdpeng@jhu.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; bcoull@hsph.harvard.edu; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Katherine Tucker <tuckerk@andrew.cmu.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>
Cc: Baxter, Lisa <Baxter.Lisa@epa.gov>; Grambsch, Anne <Grambsch.Anne@epa.gov>; Hagler, Gayle <Hagler.Gayle@epa.gov>; Nunez, Carlos <Nunez.Carlos@epa.gov>
Subject: ACE Center Directors Call

Hi All,

I am unable to attend an ACE Center Directors call this Thursday due to parenting responsibilities. However, I would like to have a discussion to follow-up on items discussed at our recent meeting and other coordination and collaborations. I'm deleting this calendar entry, but Rich Callan will be polling the group and scheduling a new meeting time. Rich will be taking over the coordination of these calls.

Regards,

Sherri

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Cc: Baxter, Lisa[Baxter.Lisa@epa.gov]; Grambsch, Anne[Grambsch.Anne@epa.gov]; Hagler, Gayle[Hagler.Gayle@epa.gov]; Nunez, Carlos[Nunez.Carlos@epa.gov]
From: Callan, Richard
Sent: Mon 6/19/2017 7:41:51 PM
Subject: RE: ACE Center Directors Call -- Rescheduling June 2017 Call

Hi All,

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From: Hunt, Sherri
Sent: Monday, June 19, 2017 1:24 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Katz, Taylor <Katz.Taylor@epa.gov>; Costa, Dan <Costa.Dan@epa.gov>; Vette, Alan <Vette.Alan@epa.gov>; Miller, Andy <Miller.Andy@epa.gov>; Hassett-Sipple, Beth <Hassett-Sipple.Beth@epa.gov>; Bell, Michelle <michelle.bell@yale.edu>; Roger Peng <rdpeng@jhu.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; bcoull@hsph.harvard.edu; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Katherine Tucker <tuckerk@andrew.cmu.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>
Cc: Baxter, Lisa <Baxter.Lisa@epa.gov>; Grambsch, Anne <Grambsch.Anne@epa.gov>; Hagler, Gayle <Hagler.Gayle@epa.gov>; Nunez, Carlos <Nunez.Carlos@epa.gov>
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Sherri

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To: Koutrakis, Petros[petros@hsph.harvard.edu]; Costa, Dan[Costa.Dan@epa.gov]
From: Devlin, Robert
Sent: Thur 5/11/2017 2:31:03 PM
Subject: RE: see you next week

I'd be honored to be part of the planning group. As you know, Dan and I will be seeing you in about 4 days. Let's talk then.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, May 11, 2017 10:18 AM
To: Costa, Dan <Costa.Dan@epa.gov>; Devlin, Robert <Devlin.Robert@epa.gov>
Subject: see you next week

Dan and Bob I was asked by the Kuwait EPA to submit a proposal (sole source). The purpose of this project is to study sources, review monitoring networks, analyze ambient data, do an exposure study and intervention study, a national air toxics assessment, and finally policy recommendations. The anticipated budget will be 10 million for three years. Other gulf countries may join the program.

I will need some epa experts for the different aspects of the program, especially for strategic planning. Retired qualified EPA scientists are welcome.

For the retired we will have funds, but for the active we can only offer business class tickets and royal hospitality. I want to put a list of five to six competent individuals. So I would like to start by inviting you.

Any suggestions

Bryan???

Tina (she was my student)???

Bachmann is good but he looks like a hippy these days and I am not sure if this will look good

Any policy people?

This is very confidential because we have not submitted the proposal yet

Of course we can discuss this next week

See you soon

To: Costa, Dan[Costa.Dan@epa.gov]; Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Thur 5/11/2017 2:18:13 PM
Subject: see you next week

Dan and Bob I was asked by the Kuwait EPA to submit a proposal (sole source). The purpose of this project is to study sources, review monitoring networks, analyze ambient data, do an exposure study and intervention study, a national air toxics assessment, and finally policy recommendations. The anticipated budget will be 10 million for three years. Other gulf countries may join the program.

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Any policy people?

This is very confidential because we have not submitted the proposal yet

Of course we can discuss this next week

See you soon

Cc: petros@hsph.harvard.edu[petros@hsph.harvard.edu]
To: Rima Habre[habre@usc.edu]
From: Costa, Dan
Sent: Thur 4/20/2017 12:20:02 AM
Subject: Re: Confidential! Ed Avol's nomination to Mehlman Award

Hi Rima
Happy and honored to do it as Ed is deserving. Monday is tough but if necessary.... EPA is chaos these days along with a couple talks I am slotted for shortly. If you have his CV etc it would be helpful. I'll keep it quiet.
Regards
Dan

Sent from my iPhone

> On Apr 19, 2017, at 7:18 PM, Rima Habre <habre@usc.edu> wrote:
>
> Hi Dan,
>
> I hope you've been well. I believe we met a while back, I was Petros' student and am now at USC working closely with Ed Avol.
>
> Given your unique perspective and relationship with Ed, I would love your help and support in nominating him for the Mehlman Award this year at ISES. It looks like the last year this award will be offered and there are at least two other nominations this year so it's somewhat competitive.
>
> "The Mehlman Award recognizes outstanding contributions that helped shape a national or state policy or provided new approaches for reduction of exposures. We did not present this award last year and would appreciate if the membership can think of deserving individuals, it is great to recognize our society members that make the world a better place by reducing exposures influencing policy!"
>
> If you have the time and would like to participate, I need a letter of support from you highlighting Ed's body of work and how it helped shape air pollution policy nationally and especially in CA, starting with his early clinical work in human exposure chamber studies, the Children's Health Study, Clean Air Research Centers Advisory Boards, port-related studies, HEI studies etc..
>
> Some examples of the impact of his work on policy (but definitely not an exhaustive list): NOx and ozone standard, law about no schools closer than 500 feet to freeways statewide, law on no multiple housing units closer than 1000 feet from freeways without filters, serving on multiple scientific advisory committees, etc..
>
> I'm working on putting together and submitting his CV and full nomination package. I'm sorry for the short turnaround, but if possible, I would really appreciate getting a letter of support from you by the end of the week/Monday.
>
> I'm more than happy to help with any aspects of this, so please let me know what I can do. I'm attaching his biosketch and a recent policy manuscript but will also forward any more recent/relevant material I find.
>
> Finally, please keep this request completely confidential, Ed does not know about it yet. I'm hoping with your help we can put together a strong nomination package and surprise him.
>
> Thanks so much,
> Rima
>
>
>

> Rima Habre, ScD
> Assistant Professor of Clinical
>
> Preventive Medicine
>
> MADRES Exposure Core Director
>
> LA DREAMERs Exposure Core Director
>
> Division of Environmental Health
> Keck School of Medicine of USC
> University of Southern California
> 2001 N Soto St, Rm 225D, MC 9237
> Los Angeles, CA 90089 (Fedex 90032)
> Tel. 323.442.8283
>
>
> <CHS policy ms 2015.pdf>
> <Avol_biosketch_Mar2016.pdf>

To: Devlin, Robert[Devlin.Robert@epa.gov]; Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 3:53:28 PM
Subject: FW: Paper submission to NEJM
Submission_NEJM_022317.pdf

Just let me know you got it

To: Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 3:31:53 PM
Subject: RE: Manuscript to send to co-authors

Hi Bob I agree, but I just wanted to give you my take on this.

I believe that too much massage of data does not really help and sometimes can be counter productive

A month ago we submitted a paper to NEJM which apparently is under review. Of course I do not know what the outcome may be. However, I am very interested in your opinion. If you think that you can keep this confidential I would like to send you a copy. Note that we are writing a follow up paper that further substantiates this hypothesis by using actual measurements of gross beta radiation as a surrogate of alpha particle exposures.

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Manuscript to send to co-authors

Thanks for the comments Petros. These models are not really in my bailiwick so I'm not confident we've set the right tone in the discussion. As you point out, its also complicated with so many co-authors. If I dis the CMAQ models Ted and the EPA will not be happy.

Were you surprised that your "simple' 10km model performed as well as the newer 1 km model with all the extras like Geochem?

Also, we're now completing a similar comparison of the various models associating acute PM exposure with health effects.

See you in May.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Saturday, March 25, 2017 7:25 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Alexandra Chudnovsky <achudnov@post.tau.ac.il>
Subject: RE: Manuscript to send to co-authors

Bob I went through the paper. It is a very nice paper with interesting results.

The conclusion to me is just use the satellite data with calibrations. No need for CMQ, GEOCHEM and other time consuming models.

This is very important in order to have more applications of remote sensing. If the procedures are simple and easy to follow then many epi researchers will use them. If the procedures can be applied only by a small group then the applications will be very limited.

Another important conclusion is that results based on monitoring data were not that bad.

The conclusions are kind neutral and I understand why. Obviously different authors have different opinions. It is a pity!!

Finally, can we acknowledge the Harvard center Alice can send you the information.

There is not attachment

Good luck

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 20, 2017 10:52 AM

To: Koutrakis, Petros <petros@hsph.harvard.edu>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>
Subject: FW: Manuscript to send to co-authors

Attached is manuscript we have prepared that describes associations between two adverse outcomes and 5 different approaches to estimate PM2.5 values. Please look it over and make sure that we've accurately portrayed the various exposure models.

I'm not sure I have the addresses of Alexandra or Qian, so please forward this to them also.

We're under a lot of pressure to get this submitted ASAP so we need your comments within the next two weeks if possible. If we don't hear back we'll assume that you are OK with the paper as is.

From: McGuinn, Laura [mailto:lmcguinn@live.unc.edu]
Sent: Monday, March 20, 2017 9:30 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Manuscript to send to co-authors

Sorry, here's the correct manuscript and supplemental material to send out, disregard my previous email.

Thanks,

Laura

From: McGuinn, Laura
Sent: Sunday, March 19, 2017 10:44 AM
To: Devlin, Robert
Subject: Manuscript to send to co-authors

Here's the most up to date version of the manuscript (and supplemental tables and figures) to send to the co-authors for feedback.

Thanks,

Laura

To: Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 8:45:58 PM
Subject: RE: Paper submission to NEJM

Sure no rush

I just want to have your reaction

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 4:17 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Paper submission to NEJM

I'll get you something in the next few days. Right now I'm engrossed with helping to fight back the proposed cuts to EPA.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 1:49 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: RE: Paper submission to NEJM

Let me know what do you think when you get a chance to read it

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 12:57 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Paper submission to NEJM

I got it.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, March 27, 2017 11:53 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>; Devlin, Robert <Devlin.Robert@epa.gov>
Subject: FW: Paper submission to NEJM

Just let me know you got it

To: petros@hsph.harvard.edu[petros@hsph.harvard.edu]
Cc: Devlin, Robert[Devlin.Robert@epa.gov]
From: Breen, Michael
Sent: Wed 12/14/2016 7:07:06 PM
Subject: collaboration on satellite-based PM2.5 for North Carolina

Hi Petros,

Nice to talk with you last week in DC.

As we discussed, we plan to link our GPS data with your PM2.5 data. Bob gave me the 1km daily satellite-based PM data from 2001-2010, which we will use to develop a Methods paper. Once we finish with the analysis, I would like to include you as a co-author.

To apply this PM data for one of our health studies, we will need predictions from 2012-2014. Please let us know when you have these.

If you would like to collaborate on other exposure modeling projects, just let me know.

Thanks.

Mike

Michael S. Breen, Ph.D.

Research Scientist

Computational Exposure Division

National Exposure Research Laboratory

Office of Research and Development

US Environmental Protection Agency

109 T.W. Alexander Drive, Mail Drop: E205-02

Research Triangle Park, NC 27711 USA

Email: breen.michael@epa.gov

Tel: 919-541-9409

To: Devlin, Robert[Devlin.Robert@epa.gov]; Schwartz, Joel[jschwrtz@hsph.harvard.edu]
Cc: McGuinn, Laura[lmcguinn@live.unc.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Alexandra Chudnovsky[achudnov@post.tau.ac.il]
From: Koutrakis, Petros
Sent: Sat 3/25/2017 11:25:12 PM
Subject: RE: Manuscript to send to co-authors

Bob I went through the paper. It is a very nice paper with interesting results.

The conclusion to me is just use the satellite data with calibrations. No need for CMQ, GEOCHEM and other time consuming models.

This is very important in order to have more applications of remote sensing. If the procedures are simple and easy to follow then many epi researchers will use them. If the procedures can be applied only by a small group then the applications will be very limited.

Another important conclusion is that results based on monitoring data were not that bad.

The conclusions are kind neutral and I understand why. Obviously different authors have different opinions. It is a pity!!

Finally, can we acknowledge the Harvard center Alice can send you the information.

There is not attachment

Good luck

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 20, 2017 10:52 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>
Subject: FW: Manuscript to send to co-authors

Attached is manuscript we have prepared that describes associations between two adverse outcomes and 5 different approaches to estimate PM2.5 values. Please look it over and make sure that we've accurately portrayed the various exposure models.

I'm not sure I have the addresses of Alexandra or Qian, so please forward this to them also.

We're under a lot of pressure to get this submitted ASAP so we need your comments within the next two weeks if possible. If we don't hear back we'll assume that you are OK with the paper as is.

From: McGuinn, Laura [mailto:lmcguinn@live.unc.edu]
Sent: Monday, March 20, 2017 9:30 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Manuscript to send to co-authors

Sorry, here's the correct manuscript and supplemental material to send out, disregard my previous email.

Thanks,

Laura

From: McGuinn, Laura
Sent: Sunday, March 19, 2017 10:44 AM
To: Devlin, Robert
Subject: Manuscript to send to co-authors

Here's the most up to date version of the manuscript (and supplemental tables and figures) to send to the co-authors for feedback.

Thanks,

Laura

To: Devlin, Robert[Devlin.Robert@epa.gov]; Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 3:53:28 PM
Subject: FW: Paper submission to NEJM
Submission_NEJM_022317.pdf

;;
Just let me know you got it

To: Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 3:31:53 PM
Subject: RE: Manuscript to send to co-authors

.....
,,,,,
Hi Bob I agree, but I just wanted to give you my take on this.

I believe that too much massage of data does not really help and sometimes can be counter productive

A month ago we submitted a paper to NEJM which apparently is under review. Of course I do not know what the outcome may be. However, I am very interested in your opinion. If you think that you can keep this confidential I would like to send you a copy. Note that we are writing a follow up paper that further substantiates this hypothesis by using actual measurements of gross beta radiation as a surrogate of alpha particle exposures.

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros
Subject: RE: Manuscript to send to co-authors

Thanks for the comments Petros. These models are not really in my bailiwick so I'm not confident we've set the right tone in the discussion. As you point out, its also complicated with so many co-authors. If I dis the CMAQ models Ted and the EPA will not be happy.

Were you surprised that your "simple' 10km model performed as well as the newer 1 km model with all the extras like Geochem?

Also, we're now completing a similar comparison of the various models associating acute PM exposure with health effects.

See you in May.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Saturday, March 25, 2017 7:25 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Alexandra Chudnovsky <achudnov@post.tau.ac.il>
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Laura

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Thanks,

Laura

To: Devlin, Robert[Devlin.Robert@epa.gov]
From: Koutrakis, Petros
Sent: Thur 3/23/2017 12:24:24 AM
Subject: Re: Manuscript to send to co-authors

Bob nice to hear from you
I will try to take a look asap
Hope to get a chance to talk to you in may during your Boston visit

Sent from my iPhone

> On Mar 20, 2017, at 10:52 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:
>
> Attached is manuscript we have prepared that describes associations between two adverse outcomes and 5 different approaches to estimate PM2.5 values. Please look it over and make sure that we've accurately portrayed the various exposure models.
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> Thanks,
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>
> Thanks,
>
> Laura
> <20170316_CATHGEN Exp Metrics.docx>
> <20170319_Supplemental Material_CATHGEN Exp Metrics.docx>

To: Devlin, Robert[Devlin.Robert@epa.gov]
Cc: McGuinn, Laura[lmcguinn@live.unc.edu]
From: Qian Di
Sent: Mon 11/28/2016 3:27:25 PM
Subject: Re: Help with 1km methods section
A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States.pdf

.....
,,,,,
Sorry for the late reply --- just back from the holiday. Here is the paper.
Qian

On Wed, Nov 23, 2016 at 8:15 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:

Thanks, Qian. Would you be able to send us a pdf of the reference you cite below?

From: Qian Di [mailto:qiandi@mail.harvard.edu]
Sent: Tuesday, November 22, 2016 9:09 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>; McGuinn, Laura <lmcguinn@live.unc.edu>

Subject: Re: Help with 1km methods section

Hi Laura,

Here is the paragraph that I added. Please let me know if there is anything needed.

--- Robert,

The ozone concentrations were from a hybrid model, which takes GEOS-Chem simulation outputs as a one input variable. Other variables go into the hybrid model as well, including meteorological variables, satellite measurements and other variables. The details were articulated in the following reference:

Di, Q., Rowland, S., Koutrakis, P. and Schwartz, J., 2016. A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States. *Journal of the Air & Waste Management Association*, (just-accepted).

Qian

On Tue, Nov 15, 2016 at 11:41 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:

Qian:

I have a question. Do the ozone values from the hybrid 1km model come from GEOS-Chem or somewhere else?

From: Qian Di [mailto:qiandi@mail.harvard.edu]
Sent: Monday, November 14, 2016 3:19 PM
To: McGuinn, Laura <lmcguinn@live.unc.edu>

Cc: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Help with 1km methods section

Great. Glad to hear that. You can send me the draft version and I can add my stuff.

Thanks,

Qian

On Mon, Nov 14, 2016 at 3:09 PM, McGuinn, Laura <lmcguinn@live.unc.edu> wrote:

> Hi Qian,
>
> Bob and I are nearing the completion of our analyses using your 1km PM2.5 and ozone data and were wondering if we could get your help with writing the methods section for these data? Alternatively, I think I have a copy of both of your papers for the data, so can start on this section, and then you can edit as needed? If it would help, I can send you a draft of the methods section for the paper?
>
> Thanks,
>
> Laura

--

Di, Qian (QD) 1-814-777-8202

Doctoral Student
Department of Environmental Health
Harvard T.H. Chan School of Public Health

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A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States

Qian Di, Sebastian Rowland, Petros Koutrakis & Joel Schwartz

To cite this article: Qian Di, Sebastian Rowland, Petros Koutrakis & Joel Schwartz (2016): A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States, Journal of the Air & Waste Management Association, DOI: 10.1080/10962247.2016.1200159

To link to this article: http://dx.doi.org/10.1080/10962247.2016.1200159

A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States

Qian Di[1], Sebastian Rowland[1], Petros Koutrakis[1], Joel Schwartz[1]

[1]Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, 02215, U.S.A

ABOUT THE AUTHORS

Qian Di is a graduate student at the Department of Environmental Health, Harvard T.H. Chan School of Public Health. Email: qiandi@mail.harvard.edu

Sebastian Rowland is a graduate student at the Department of Environmental Health, Harvard T.H. Chan School of Public Health.

Petros Koutrakis is a professor at the Department of Environmental Health, Harvard T.H. Chan School of Public Health.

Joel Schwartz is a professor at the Department of Environmental Health, Harvard T.H. Chan School of Public Health.

Abstract. Ground-level ozone is an important atmospheric oxidant, which exhibits considerable spatial and temporal variability in its concentration level. Existing modeling approaches for ground-level ozone include chemical transport models, land-use regression, Kriging, and data fusion of chemical transport models with monitoring data. Each of these methods has both strengths and weaknesses. Combining those complementary approaches could improve model performance. Meanwhile, satellite-based total column ozone, combined with ozone vertical profile, is another potential input. We propose a hybrid model that integrates the above variables to achieve spatially and temporally resolved exposure assessments for ground-level ozone. We used a neural network for its capacity to model interactions and nonlinearity. Convolutional layers, which use convolution kernels to aggregate nearby information, were added to the neural

network to account for spatial and temporal autocorrelation. We trained the model with AQS 8-hour daily maximum ozone in the continental United States from 2000 to 2012 and tested it with left out monitoring sites. Cross-validated R^2 on the left out monitoring sites ranged from 0.74 to 0.80 (mean 0.76) for predictions on 1 km×1 km grid cells, which indicates good model performance. Model performance remains good even at low ozone concentrations. The prediction results facilitate epidemiological studies to assess the health effect of ozone in the long term and the short term.

Implications

Ozone monitors do not provide full data coverage over the U.S., which is an obstacle to assess the health effect of ozone when monitoring data are not available. This paper used a hybrid approach to combine satellite-based ozone measurements, chemical transport model simulations, land-use terms and other auxiliary variables to obtain spatially and temporally resolved ground-level ozone estimation.

INTRODUCTION

Ground-level ozone is a serious public health concern. The adverse effects of ozone are well documented including respiratory symptoms (Schwartz et al. 1994, Hao et al. 2015, Gent et al. 2003), the development of asthma (McConnell et al. 2002, Sousa, Alvim-Ferraz, and Martins 2013), airway inflammation (Koren et al. 1989, Tank et al. 2011), and mortality (Franklin and Schwartz 2008, Turner et al. 2015, Atkinson et al. 2016, Bell and Dominici 2008). These Health effects have been reported for both long- and short-term exposures (Jerrett et al. 2009, Bell

2004). Ozone is one of criteria pollutants regulated by the Environmental Protection Agency (EPA) based on maximum of 8-hour average. Ground-level ozone is a product of photochemical reactions involving NO, NO_2, hydrocarbons, nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Ground-level ozone concentration is typically characterized by a diurnal variability with peak concentrations occurring at daytime. Many parameters, including local combustion sources, land-surface characteristics and atmospheric conditions, influence ozone formation and removal, resulting in high spatial and temporal variability of ozone concentration. Therefore, predicting ozone concentrations is challenging, especially at fine resolutions.

Fine spatial and temporal resolutions are critical to assessing human exposures for health studies. Many early epidemiological studies used ozone measurements from the nearest monitoring sites to assign exposure (Jerrett et al. 2009). This approach introduces non-differential measurement error, because it fails to capture ozone scavenging by nitric oxide (NO) and other sources of local variability.

Other approaches of accessing ozone concentrations involve spatial interpolation, land-use regression, satellite-based data modeling, and chemical transport model. **Spatial interpolation**, such as inverse-distance weighting (Breton et al. 2012) and Kriging (Tranchant and Vincent 2000), was used to estimate ozone exposures for epidemiology studies. Often, a radius threshold is chosen in interpolation (Bell 2006). Spatial interpolation has the advantage of low computation cost and reduces measurement error, but often generates over-smoothed distributions, which inadequately represents local variability (Abraham and Comrie 2004). Due to complex transport and chemistry, terrain variability can cause ozone concentration to vary remarkably within a short distance, which imposes an even greater challenge for spatial interpolation (Loibi et al. 1994). **Land-use regression** (LUR) assumes that land-use terms are predictors for ozone level and uses covariates such as traffic, population density and elevation to model ozone (Malmqvist et al. 2014). LUR is relatively easy to implement and has satisfying model performance at small scales, but has limited capacity to capture temporal variations and can miss some short-term and regional patterns (Hoek et al. 2008). **Satellite** observations measure ozone over larger spatial and temporal scales than most LURs. Most satellite ozone measurements are column-based, such as TOMS (Total Ozone Mapping Spectrometer), GOME (Global Ozone Monitoring Experiment) (Burrows et al. 1999) and OMI (Ozone Monitoring Instrument) (Levelt et al. 2006). Some satellite measurements also provide vertical distribution of ozone, including SBUV (Solar Backscatter Ultra Violet), GOME and later OMI. Two OMI ozone data products, produced by the OMI-TOMS and the OMI-DOAS retrieval algorithms, demonstrate high agreement with total column ozone observation at a global scale, with about 1% disagreement (Balis et al. 2007, McPeters et al. 2008). At ground level, OMI ozone observations are close to ground monitor-based mean concentrations but at higher elevations these observations deviate from the monitors (Wang et al. 2011). The discrepancy can be as large as 20% (Liu, Bhartia, et al. 2010).

A **chemical transport model** (CTM) is a more advanced tool of estimating ozone, which simulates the formation, dispersion and deposition of ozone. CTMs, such as GEOS-Chem (Bey et al. 2001), MOZART (Brasseur et al. 1998) and CMAQ (Byun and Schere 2006) have been applied to estimate ground-level ozone at city level (Lei et al. 2007, Sokhi et al. 2006), country level (Liu, Zhang, et al. 2010, Tong and Mauzerall 2006), continent level (Fusco and Logan 2003, Pfister et al. 2008) or beyond. Due to limitations of both computational capacity and the spatial resolution of emission inventories, ozone estimation from CTM is usually not spatially resolved enough to assess exposure at local scale. Typical scales are 4°×5°, 2.0°×2.5°, 0.500°×0.667° or 0.2500°×0.3125°, although CMAQ-Urban can produce very fine scale predictions in selected urban locations with good emission inventories. However, CTMs deviate substantially from real world measurements due to imperfect data and chemistry, and these errors tend to increase at finer time or spatial scales. One limitation of many ozone models is that their performance is only tested against the monitoring sites used to train the models, which does not test the validity of the model in areas without monitoring data. Cross-validation can test model validity at unmonitored areas by leaving out monitors during model training, and subsequently testing the correlation between the model and the left out monitors.

With both strengths and weaknesses, the aforementioned approaches are complementary to each other. This study proposes a hybrid approach, which integrates informative variables and existing ground-level ozone modeling approaches into a neural network-based framework. Ten-fold cross-validation was used to test model performance and avoid overfitting. After model training, we predicted ground-level ozone at nationwide 1 km×1 km grid cells and produced spatially- and temporally-resolved ozone exposure assessments, which can be used by epidemiologists to assess the acute and chronic health effects of ozone.

A similar hybrid approach has been applied to assess human exposures to $PM_{2.5}$ mass and chemical components (Di et al. 2015, Di et al. 2016, Kloog et al. 2014, Kloog et al. 2011). This study applies a hybrid approach similar to the previous model of $PM_{2.5}$, but incorporates additional variables due to ozone's distinct gaseous nature and chemical characteristics. We present a new model for ground-level ozone that relies on multiple data sources and the application of neural network with convolutional layers.

DATA AND METHODS

Study Domain

The spatial area is the continental United States, which includes the 48 contiguous states and Washington, D.C. The study period is 2000-2012, covering 4,749 days.

Monitoring Data

Monitoring data for ozone concentrations across the study area were collected by the USEPA Air Quality System (AQS). There were 1,877 monitoring sites available within the study area during the study period, but some of them reported data for a subset of the study period or reported data intermittently. Monitoring sites were densely located in the Eastern United States and the Western Coast, while the Mountain Region and other remote areas had fewer monitoring sites (Fig. 1). We calibrated the model to the 8-hour daily maximum ozone (daily 8hr-max ozone). In this paper, unless specified otherwise, the term "ozone" refers to daily 8hr-max ozone at ground level.

Chemical Transport Model Output

We used GEOS-Chem Version 9.0.2 to simulate ozone formation, dispersion and deposition. GEOS-Chem incorporates meteorological inputs, emission inventories and atmospheric chemical reactions. Its methodology has been described in previous literature (Bey et al. 2001). We first performed a global 2.0°×2.5° simulation and exported boundary conditions. We then performed a nested grid simulation at 0.500°×0.667° for the North America. For years from 2000 to 2004, 2.0°×2.5° outputs were used instead because meteorological inputs at 0.500°×0.667° were not available.

Satellite-based Ozone Measurements

The OMI instrument is on board the EOS-Aura satellite, which was launched in July 2004 (Levelt et al. 2006). OMI's raw data was processed by two distinct algorithms, which yielded two different data products. Data product OMTO3e (Version 003) was produced from the TOMS Version 8.5 algorithm, which is based on TOMS Version 8 algorithm (Bhartia and Wellemeyer 2002). The other data product OMDOAO3e (Version 003) was produced from OMI-DOAS algorithms (Veefkind et al. 2006). The two algorithms generally agree with each other, with a mean difference in the total column ozone below 3%, though larger differences occur at high latitude areas and over clouds (Kroon et al. 2008). Both data products have a spatial resolution of 0.25°×0.25° and are available since July 2004.

Ozone Vertical Profile

Satellite instruments measure total column ozone, however the vertical distribution profile is needed to obtain ground-level ozone concentration. We adopted an approach similar to the approach used in modeling $PM_{2.5}$, where AOD is a column measurement of aerosol and researchers used the vertical profile from a chemical transport model to calibrate AOD to ground-based $PM_{2.5}$ (Liu 2004, van Donkelaar et al. 2010). GEOS-Chem simulates ozone concentrations at different layers. We defined a scaling factor as the fraction of ground-level ozone in the total column ozone, and used this factor to calibrate satellite-based column ozone to ground-level ozone. One advantage of GEOS-Chem ozone vertical profile is the absence of missing values. GEOS-Chem tropospheric ozone predictions agree with monitor observations in terms of the overall characteristics, but significant differences exist by region and by season (Liu et al. 2006). OMI also provides ozone vertical profile (data product OMO3PR Version 003) (Ahmad et al. 2003), in which an optimal estimation algorithm adjusts ozone in each atmospheric layer based on *a priori* information and minimizes the difference between modeled and measured ozone (Rodgers 2000). Although some missing values occur occasionally, comparison of retrieved and measured ozone indicates good agreement (Veefkind, Kroon, and de Haan 2009).The OMI ozone profile has a spatial resolution of 13 km×48 km. We linearly interpolated the data at all missing values.

NO_x, SO_2, VOC Data

Ozone precursors include nitrogen oxides (NO_x), carbon monoxide (CO), methane (CH_4), and volatile organic compounds (VOCs). Ozone precursors react with the presence of sunlight and form ozone. NO, in contrast, decreases ozone concentration by inducing ozone scavenging (Graedel, Farrow, and Weber 1977). Although emission inventories of these compounds are used in the GEOS-Chem model, they lack the temporal resolution of the monitoring data. To account for those relevant atmospheric reactions, we included AQS daily measurements of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), NO_x, and VOCs into our ozone model. AQS measurements are point measurements and sparsely located. We applied distance-decay functions to aggregate point data from monitors into convolutional layers (Section Convolutional Layer, Supplementary Material).

In order to obtain higher spatial and temporal coverage, we also used satellite-based total column SO_2 and total column NO_2 from OMI data products (OMSO2e Version 003 and OMNO2d Version 003) (Krotkov et al. 2011).

Meteorological Data

Our model used meteorological fields from the NCEP North American Regional Reanalysis data. This dataset assimilates multiple measurements from land-surface, ship, radiosonde, pibal, aircraft, satellite and other sources, with a resolution of 0.3° (about 32 km) at the daily level (Kalnay et al. 1996). The reanalysis dataset was chosen because it has both relatively high spatiotemporal resolution and no missing values. We used 16 meteorological variables in order to fully capture meteorological conditions and account for complex atmospheric processes. The variables included air temperature, accumulated total precipitation, downward shortwave radiation flux, accumulated total evaporation, planetary boundary layer height, low cloud area fraction, precipitation rate, precipitable water for the entire atmosphere, pressure, specific humidity at 2 m, visibility, wind speed, medium cloud area fraction, high cloud area fraction and, albedo. Wind speed was computed as the vector sum of u-wind (east-west component of the wind) at 10m and v-wind (north-south component) at 10m.

Land-Use Terms

Land-use terms are proxies for ozone formation or removal, and capture spatial variations at local scale, which may not be measured by satellite or modeled by GEOS-Chem. The detailed procedure of processing elevation, road density, NEI (National Emissions Inventory), population density, percentage of urban and NDVI (normalized difference vegetation index) has been specified somewhere else (Kloog et al. 2012). We used two variables to approximate vegetation: the percentage of vegetation from NCEP North American Regional Reanalysis data and 16-day 1-km MODIS NDVI data product MOD13A2 (Didan 2015). For days without NDVI values, we linearly interpolated values from neighboring days.

Regional and Monthly Dummy

Regional and monthly dummy variables were used to capture different associations between the above variables and monitored ozone by season and climate type. The major climate types were used to define the regional dummy variable (Kottek et al. 2006).

Neural Network

We used a neural network for its capacity to model nonlinearity and interactions among variables (Bishop 1995, Haykin and Network 2004). The target variable was monitored ozone from the AQS network and the predictor variables included the aforementioned variables. The input variables were available for the entire study area. Some variables had a small proportion of missing values and we estimated the missing data using linear interpolation (Table S2, supplementary material). Not all variables were available during the entire study period. For each year, we fitted a neural network with available variables in that year. Most existing studies fitted models with *in situ* information, the values of each variable at the monitoring sites; however, information about neighboring areas can be also informative. For instance, nearby traffic volume influences *in situ* ozone levels by either providing ozone precursors or scavenging ozone. To incorporate the nearby information into the neural network, we used convolutional layers (LeCun and Bengio 1995). A convolutional layer is computed by applying a convolution kernel (e.g., mean, inverse distance weighted mean) to the inputs in order to compute a scalar summary of the neighboring cells, which is then used as an additional predictor. By choosing kernels, we obtained different aggregations of neighboring information, which gave the neural network more flexibility to capture spatial autocorrelation and improved model fit. We computed convolutional layers for each land-use variable, predicted ozone of nearby areas, and predicted ozone of proceeding and subsequent days. To create the convolutional layers for predicted ozone, we first fitted the neural network and obtained intermediate ozone predictions. Then we computed spatial and temporal convolutional layers for predicted ozone and fitted the neural network again with those convolutional layers (Fig. S2). The details of convolutional layers and fitting a neural network are presented in the supplementary material.

We used ten-fold cross-validation to validate neural network results, in which all monitors were randomly divided into 10 splits. We then trained a neural network with 9 splits of the monitors and made ozone predictions for the remaining 1 split. The process was repeated nine times and made ozone predictions for the other 9 splits. Combining the predicted ozone from the 10 splits together yielded ozone predictions for all monitors. We calculated total R^2, spatial R^2 and temporal R^2 for all monitors as well as by region and season to evaluate model performance. Calculations of R^2 and other metrics of model performance (bias and slope) are specified in the supplementary material.

To make ozone predictions, we trained a neural network with all monitors. The trained neural network was used to predict ozone at 1 km×1 km grid cells for the whole study area during the entire study period. We prepared input variables at 1 km×1 km grid cells and made ozone predictions with the trained neural network. We linearly interpolated the data if missing values were present. All programming work was implemented in Matlab (version 2014a, The MathWorks, Inc.).

RESULTS

After conducting ten-fold cross-validation, total R^2 ranged from 0.74 to 0.80 with mean R^2 = 0.76 (Table 1). Slope was near 1; bias was about 1.20 ppb for the whole concentration range and 2.82 ppb below 75 ppb (Table 1, Table S3). Model performance did not vary much by year; nor was there any temporal trend in model fit. In contrast, model performance varied by season, with highest R^2 observed in autumn, followed by summer, spring and winter (Table 2). By region, model performance in the Middle Atlantic, South Atlantic, East North central, West South Central and Pacific States was near or above the national average; while the New England, Mountain and West North Central States were below the national average (Table 3). Above regional division is from the U.S. Census Bureau (Table S1, Fig. S7). Figure 2 visualizes model fits for the study area. Wyoming, Montana, Western Colorado, Eastern Washington State, Eastern Tennessee and Marine had lower fits than other states.

Figure 3 visualizes the spatial pattern of ozone in the study area. The Mountain States had the highest ozone levels for all seasons. Areas around the Appalachian Mountain also witnessed high ozone levels, although less so. The Eastern United States, with much lower ozone year round, experienced higher ozone levels in summer. Figure 3 also presents low concentrations in cities and along highways. In terms of temporal trend, Figure 4 presents a general decreasing trend of ozone, although less obvious in some regions.

DISCUSSION

This study proposed a hybrid model framework, which integrated satellite-based data, CTM outputs, ozone vertical profiles, meteorological variables, land-use terms and other atmospheric compounds that were related to ozone formation or deposition. Convolutional layers aggregated nearby information and improved model fit. The average cross-validated R^2 between predicted and monitored daily 8hr-max ozone was 0.76 (0.74~0.80 by year). Few existing studies have ever modeled 8-hour maximum ground-level ozone at daily basis or attempted to make predictions at nationwide 1 km×1 km grid cells. We believe that this level of temporal/spatial coverage and model performance is an improvement over previous ozone prediction approaches. Epidemiological studies investigating the acute and chronic effects of ozone will benefit from more accurate and granular exposure assessments.

Our hybrid approach has several advantages and innovations. First, model performance surpasses existing studies. Some previous studies adopted land-use regression, Kriging or other methods and achieved RMSE > 10 ppb in Belgium (Hooyberghs et al. 2006); RMSE > 10 ppb in Italy (Carnevale et al. 2008); daily $R^2 = 0.653$ in Quebec (Adam-Poupart et al. 2014). Our hybrid model outperformed land-use regression results, with averaged cross-validated annual $R^2 = 0.76$ and RMSE = 7.36 ppb. Another improvement is that LUR is usually constrained to specific locations, while our hybrid model covers the entire continental United States. In terms of CTMs, some CMAQ simulations achieved normalized mean error (NME) less than 35% over the continental United States in summer (Tong and Mauzerall 2006); improved to NME 17.9% but focused on the Eastern United States (Appel et al. 2007); and continued to obtain NME between 17.7% and 21.7% (Zhang et al. 2009). CMAQ simulation was becoming better over time, but our hybrid model still outperformed it with a cross-validated NME = 13.13%. Combing multiple CTM simulations and comparing with monitored ozone, some researchers obtained mean R^2 = 0.57 for the continental United States for the whole year (Reidmiller et al. 2009), compared with mean $R^2 = 0.76$ in our study. This indicates that our hybrid model surpasses CTM simulations as a whole. Besides, convolutional layers take neighboring information into account, which is also applicable to other studies. Other methods, such as Kriging, have been widely used to aggregate nearby information in ozone modeling. For a convolutional layer, the specific aggregation depends on the kernel function, which is more versatile than Kriging. More importantly, being an input layer of a neural network, a convolutional layer can have complex interaction with other variables, which can better capture much more complex nonlinear atmospheric processes. By introducing convolutional layers, this study introduces a new way of incorporating neighboring information to improve model performance.

We integrated multiple data sources into a single ozone-modeling framework and improved model fit. Not all of the variables contributed equally to model performance. Satellite-based ozone measurement, GEOS-Chem simulations and land-use terms were critical to model performance. Hence, previous studies also combined land-use regression with chemical transport model (Akita et al. 2014), or land-use regression with Kriging (Wang et al. 2015), at the regional or municipal scales. Other variables including regional dummy variables, and certain meteorological variables played an auxiliary role. Some variables are complementary to each other. For example, satellite-based instruments, like OMI, have daily measurements with a large spatial coverage, but their values are averaged column measurements of ozone for a large volume of air. AQS monitors measure ground-level ozone at specific locations. Thus, satellite-based measurements cannot capture variability at small scales like monitors do (Wang et al. 2011). On the other hand, land-use terms are proxies for local emission which gives rise to local variability, but they usually do not provide much information on the temporal variability. Land-use terms and satellite observations are complementary to each other because land-use terms are at small local scales and satellite observations have wide time and space coverage. Combining both data sets overcomes weaknesses and improves the model. The use of neural network rather than a regression did not singularly drive model performance; a study also used neural network with only land-use terms and achieved model performance inferior to ours (RMSE > 10 ppb) (Carnevale et al. 2008).

We found an east-west gradient of ozone concentration (Fig. 3). High concentrations in the Western United States and Mountain States are attributable to factors including high elevation, deep boundary layer, large-scale subsidence, slow ozone deposition to the arid terrain and slow ozone loss caused by dry conditions (Fiore et al. 2002). The high ground-level ozone in the Mountain States reflects stratospheric intrusion, which can produce some transient peak ozone concentrations at ground level (Davies and Schuepbach 1994). Compared with the high concentrations in the Mountain States, urban areas had lower ozone. Other air pollutants (e.g. NO) react with ozone and cause ozone scavenging in urban areas, such as San Francisco, Los Angeles, New York City, Houston and Chicago as well as areas along highways (Fig. 3). For the same reason, we observed higher ozone concentrations in rural areas than urban areas in general (Fig. 5). We found a general trend of decreasing concentrations over time that agrees with trends observed in monitoring data alone (Camalier, Cox, and Dolwick 2007, Cox and Chu 1996), but the trend is less evident at the national level and in several regions (Fig. 4). Figure 5 presents temporal trend by season. In spring and autumn there is an increasing trend over time, because NO emission controls in recent years have reduced ozone scavenging and raised background ozone levels. The decreasing summer averages reflect the implemented emission control policies for ozone precursors, but this trend was reversed after the recession. The temporal trend in each region may deviate from the national trend (Fig. S4). The regional discrepancies and different effects of emission control in spring, summer, and autumn have been described in previous literature (Cooper et al. 2012). The increasing trend in winter is almost consistent in all regions, which is related to suppressed ozone scavenging due to decreasing NO_x concentration via NO_x titration (Austin et al. 2014, Jhun et al. 2014). This suggests a side-effect of controlling air pollutant: pollution emission control (e.g. NO_x) may ironically lead to ozone increase under certain conditions (Li et al. 2013).

Model performance was good at typical concentrations. Figure 6 presents that the linearity between predicted and monitored ozone held below 110 ppb. Furthermore, model performance was still good with mean R^2 almost unchanged below 75 ppb, the EPA 8hr-max ozone standard (Table S3). This performance will enable epidemiologists to assess the adverse effect of ozone even at low concentrations. Conversely, the model's linearity had much uncertainty above 120 ppb due to insufficient data (Fig. 6); meanwhile, model performance dropped at high concentrations (Fig. S5). The inability to accurately predict extreme values is a limitation of our model, which may limit its usage in epidemiological studies that focus on peak concentrations. In terms of model performance over time, there was a slight decreasing trend in temporal R^2, which may result from out-of-date land-use variables. Population density was retrieved for year 2000 and assumed to be constant over time. Population density data for year 2000 do not reflect population density in recent years. Updating population density to be time-varying may improve model performance. This hybrid approach used daily 8hr-max ozone as ozone metric, which avoided noisy ozone fluctuations at night and improved model fit. Although our model performed less well in some remote and sparsely populated areas at daily basis, the annual average demonstrated less discrepancy (Fig. S6).

Some limitations remain in our hybrid approach. First, this hybrid approach combines multiple datasets into a single framework and thus requires many variables that may not be available to countries where public available datasets are sparse. Second, the prediction interval is not available in the prediction results. A formal assessment of uncertainty level is critical in epidemiological studies to determine statistical power. Both issues are worthy of further investigations.

CONCLUSION

In this paper, we introduced a hybrid model that predicts daily 8hr-max ozone across the continental United States. The main feature of this model is its ability to integrate information from multiple data sources. Specifically, we integrated data from satellite-based ozone measurements, ozone vertical profile, CTM outputs, land-use terms, meteorological variables, concentrations of ozone precursors and other air pollutants, NDVI, and regional/monthly dummy variables. The hybrid model used neural network with convolutional layers, which aggregated information from neighborhood to improve model fit. We calibrated the model using AQS daily 8hr-max ozone measurements. Mean cross-validated R^2 was 0.76, ranging from 0.74 to 0.80 for the entire United States. The model performed better in the Eastern United States. The trained neural network predicted daily 8hr-max ozone at nationwide 1 km×1 km grid cells from 2000 to 2012. These ozone assessments can help scientists investigate the health effect of ozone.

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Table 1. Cross-validated total R^2, spatial R^2, temporal R^2, and corresponding MSE between monitored and predicted ozone in each year for the study area.

Year	Total R^2	RMSE	Spatial R^2	RMSE	Temporal R^2	RMSE	Bias	Slope
2000	0.79	8.09	0.82	3.30	0.78	7.42	1.38	0.99
2001	0.78	8.12	0.80	3.51	0.77	7.34	1.21	0.99
2002	0.80	8.09	0.82	3.30	0.80	7.39	1.12	0.99
2003	0.77	7.98	0.78	3.21	0.77	7.33	1.33	0.99
2004	0.76	7.44	0.76	2.98	0.76	6.83	1.34	0.99
2005	0.78	7.84	0.78	3.11	0.77	7.22	1.37	0.99
2006	0.77	7.52	0.78	2.95	0.76	6.94	1.10	0.99
2007	0.77	7.32	0.85	2.88	0.76	6.76	1.13	0.99
2008	0.76	7.12	0.82	2.75	0.75	6.58	1.09	0.99

2009	0.76	6.61	0.79	2.57	0.75	6.13	1.18	0.98
2010	0.74	6.90	0.82	2.58	0.73	6.42	1.31	0.98
2011	0.75	7.01	0.80	2.72	0.74	6.50	1.08	0.99
2012	0.78	6.76	0.83	2.59	0.77	6.29	0.96	0.99
Mean	0.76	7.36	0.80	2.91	0.75	6.79	1.20	0.99

Note: Unit for RMSE (root-mean-square error) is ppb; the unit for bias is ppb; the same below.

Table 2. Cross-validated total R^2, spatial R^2, temporal R^2, and corresponding MSE between monitored and predicted ozone in each year divided by season. The definition of seasons was specified in Fig. 2.

Year	Spring R^2	RMSE	Summer R^2	RMSE	Autumn R^2	RMSE	Winter R^2	RMSE	Annual R^2	RMSE
2000	0.70	7.78	0.73	9.23	0.77	7.72	0.69	6.30	0.79	8.09
2001	0.71	7.54	0.71	9.59	0.74	7.61	0.69	6.27	0.78	8.12
2002	0.67	6.97	0.75	9.70	0.80	7.87	0.66	6.34	0.80	8.09
2003	0.71	7.55	0.71	9.19	0.75	7.70	0.67	6.10	0.77	7.98
2004	0.68	7.03	0.70	8.42	0.77	7.22	0.65	6.36	0.76	7.44
2005	0.67	7.16	0.70	9.18	0.77	7.52	0.70	6.05	0.78	7.84
2006	0.65	7.08	0.70	8.93	0.73	6.89	0.68	5.66	0.77	7.52
2007	0.71	6.76	0.71	8.59	0.75	7.06	0.66	5.91	0.77	7.32
2008	0.68	6.48	0.70	8.34	0.74	6.80	0.69	5.47	0.76	7.12

2009	0.68	6.34	0.70	7.43	0.75	6.41	0.66	5.83	0.76	6.61
2010	0.64	6.53	0.69	7.77	0.75	6.73	0.65	6.16	0.74	6.90
2011	0.63	6.51	0.69	8.08	0.75	6.68	0.65	5.36	0.75	7.01
2012	0.69	6.28	0.72	8.09	0.73	6.39	0.65	5.95	0.78	6.76
Mean	0.68	6.92	0.71	8.66	0.75	7.12	0.67	5.98	0.76	7.36

Table 3. Cross-validated total R^2, spatial R^2, temporal R^2, and corresponding MSE between monitored and predicted ozone in each year divided by U.S. Census Divisions.

Year	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific	National
2000	0.70	0.81	0.79	0.74	0.78	0.74	0.79	0.77	0.80	0.79
2001	0.70	0.83	0.81	0.73	0.79	0.74	0.76	0.73	0.78	0.78
2002	0.74	0.85	0.85	0.76	0.82	0.79	0.76	0.74	0.78	0.80
2003	0.68	0.81	0.81	0.70	0.77	0.74	0.76	0.76	0.78	0.77
2004	0.63	0.81	0.77	0.71	0.76	0.72	0.76	0.74	0.78	0.76
2005	0.69	0.82	0.81	0.76	0.79	0.74	0.76	0.73	0.76	0.78
2006	0.71	0.82	0.79	0.74	0.76	0.72	0.77	0.73	0.76	0.77
2007	0.69	0.82	0.82	0.73	0.78	0.75	0.77	0.73	0.75	0.77
2008	0.71	0.82	0.77	0.69	0.80	0.73	0.74	0.72	0.76	0.76

2009	0.72	0.78	0.77	0.72	0.75	0.75	0.76	0.69	0.77	0.76
2010	0.71	0.80	0.72	0.69	0.76	0.68	0.74	0.68	0.75	0.74
2011	0.66	0.78	0.75	0.67	0.75	0.72	0.77	0.68	0.75	0.75
2012	0.69	0.82	0.81	0.78	0.75	0.76	0.75	0.74	0.77	0.78
Mean	0.60	0.73	0.69	0.62	0.68	0.62	0.69	0.67	0.73	0.70

Figure 1. Ozone monitoring sites in the United States.

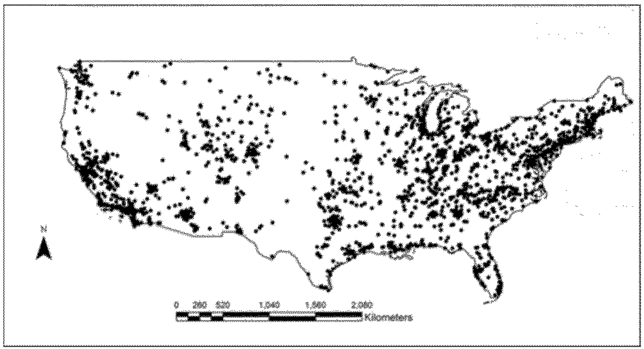


Figure 2. Model performance in the continental United States. This figure visualizes the total R^2 between monitored and predicted ozone. We interpolated R^2 to areas without monitors using Kriging interpolation. Spring was defined as March to May; summer was defined as June to August; autumn was defined as September to November; winter was from December to February of the next year (same below).

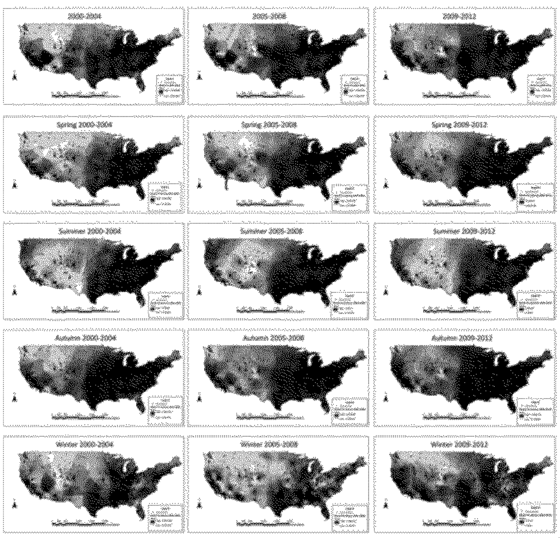


Figure 3. Spatial distribution of predicted ozone. The trained neural network predicted ozone at 1 km×1 km grid cells. Those figures visualize annual averages and seasonal averages of predicted ozone for 2000~2004, 2005~2008 and 2009~2012.

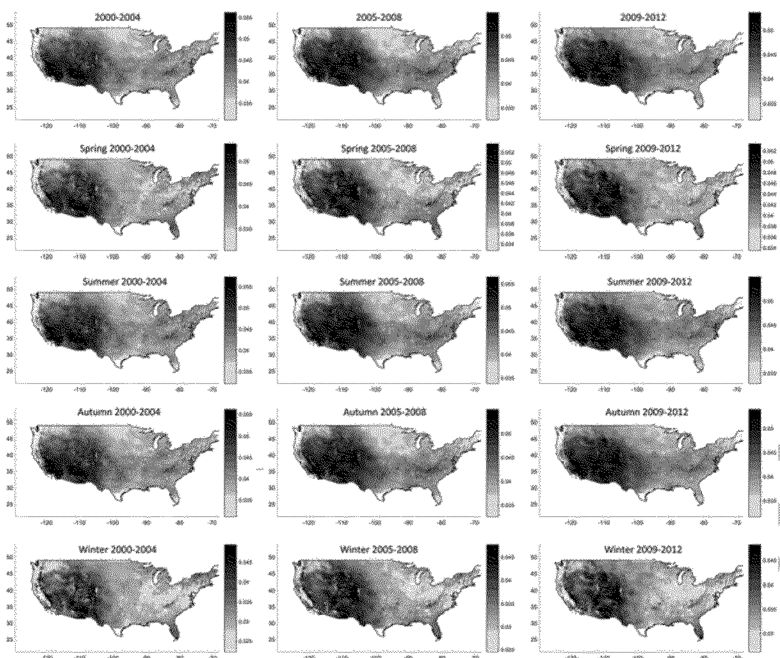


Figure 4. Regional trend in ozone levels at national and regional levels. Concentration is defined by annual fourth maximums of daily 8hr-max.

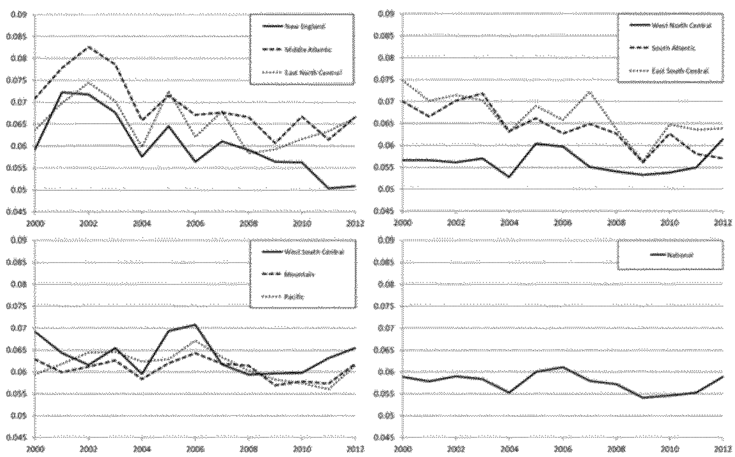


Figure 5. Seasonal averages by urban and rural area. Seasonal averages were computed by averaging predicted ozone at all 1 km×1 km grid cells in urban or rural areas. Urban areas are defined by developed areas above 50% based on National Land Cover Database (NLCD) 2001, 2006 and 2011 (Fry et al. 2011, Xian et al. 2011).

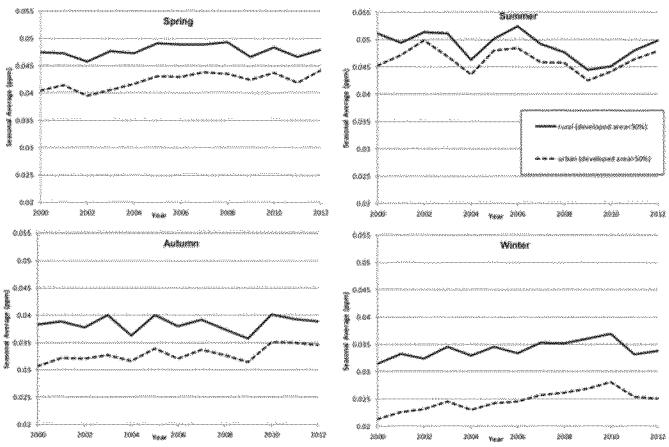
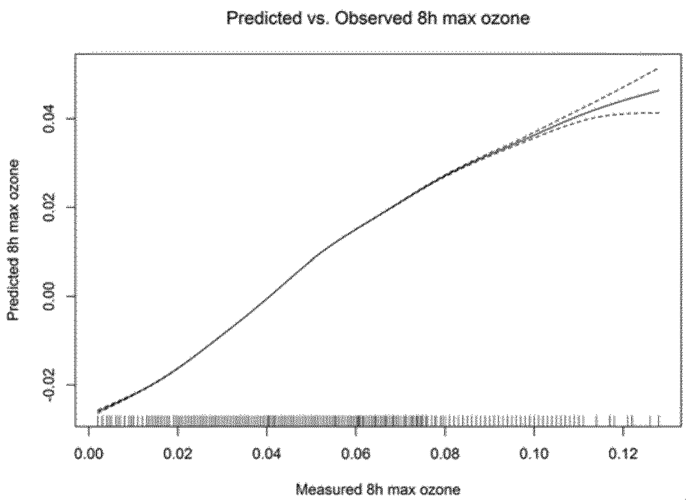


Figure 6. Relationship between measured and predicted ozone. We fitted a regression of predicted ozone on monitored ozone with penalized spline. To assess the linearity between predicted and monitored ozone, we did not specify the degrees of freedom. This figure is for year 2009.



To: McGuinn, Laura[lmcguinn@live.unc.edu]
Cc: Devlin, Robert[Devlin.Robert@epa.gov]; Schneider, Alexandra, Dr.[alexandra.schneider@helmholtz-muenchen.de]
From: Qian Di
Sent: Wed 1/11/2017 11:24:27 PM
Subject: Re: Meteorology data?

Hi Laura,

Thanks for your email and it seems to be some progress going on.

I used the NOAA NCEP reanalysis data set for meteorological inputs (https://www.esrl.noaa.gov/psd/data/gridded/data.narr.html). The original daily data set has 32 km resolution and I linearly interpolated to each 1 km grid cell. You can download and process the hdf files; or you can send me a list of points of interests (in csv files, with three column, id, latitude, longitude). I am back to my hometown in China but I think I can process the data remotely.

Qian

On Thu, Jan 12, 2017 at 1:37 AM, McGuinn, Laura <lmcguinn@live.unc.edu> wrote:

Hi Qian,

We're working on some analyses looking at associations between short-term air pollution exposure and lipoprotein outcomes using your 1km PM2.5 data for the state of North Carolina. We wanted to incorporate meteorology data in these analyses, and thought it would be best to have the meteorology data at the same resolution as the air pollution data (i.e. 1km). We were wondering if you might have access to this 1km meteorology data? Or if not, if there was any way you could direct us to where we could possibly find these data?

Thanks for your help!

Best,

Laura

--
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To: Devlin, Robert[Devlin.Robert@epa.gov]; McGuinn, Laura[lmcguinn@live.unc.edu]
From: Qian Di
Sent: Wed 11/23/2016 2:08:43 AM
Subject: Re: Help with 1km methods section
CATHGEN_Methods_Nov142016.docx

Hi Laura,

Here is the paragraph that I added. Please let me know if there is anything needed.

--- Robert,

The ozone concentrations were from a hybrid model, which takes GEOS-Chem simulation outputs as a one input variable. Other variables go into the hybrid model as well, including meteorological variables, satellite measurements and other variables. The details were articulated in the following reference:

Di, Q., Rowland, S., Koutrakis, P. and Schwartz, J., 2016. A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States. *Journal of the Air & Waste Management Association*, (just-accepted).

Qian

On Tue, Nov 15, 2016 at 11:41 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:

Qian:

I have a question. Do the ozone values from the hybrid 1km model come from GEOS-Chem or somewhere else?

From: Qian Di [mailto:qiandi@mail.harvard.edu]
Sent: Monday, November 14, 2016 3:19 PM
To: McGuinn, Laura <lmcguinn@live.unc.edu>
Cc: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Help with 1km methods section

Great. Glad to hear that. You can send me the draft version and I can add my stuff.

Thanks,

Qian

On Mon, Nov 14, 2016 at 3:09 PM, McGuinn, Laura <lmcguinn@live.unc.edu> wrote:

Hi Qian,

Bob and I are nearing the completion of our analyses using your 1km PM2.5 and ozone data and were wondering if we could get your help with writing the methods section for these data? Alternatively, I think I have a copy of both of your papers for the data, so can start on this section, and then you can edit as needed? If it would help, I can send you a draft of the methods section for the paper?

Thanks,

Laura

--

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Methods

Study Population

Study participants came from the CATHeterization GENetics (CATHGEN) cohort, a large, sequential cohort with participants primarily from North Carolina presenting to the Duke University Medical Center Cardiac Catheterization Clinic between 2001 and 2011 (Kraus et al. 2015). Participants underwent a cardiac catheterization and coronary angiography in order to diagnose and treat coronary artery disease. Clinical information was obtained from an intake questionnaire at the time of catheterization as well as medical records. All subjects received and signed informed consent forms prior to enrollment, and CATHGEN has been approved by and follows all Duke University Institutional Review Board policies.

Exposure data for the 10km satellite-based $PM_{2.5}$ estimates were only available from January 1, 2002 through December 31, 2009, thus exposure data for all exposure assignment approaches were restricted to this timeframe for comparability across exposure metrics. A yearly average was created for each participant for each exposure metric using the 365 days of exposure prior to each participant's catheterization date. Therefore, patients were included in the current analysis if they resided in North Carolina and their catheterization procedure was performed from January 1, 2003 through December 31, 2009. Residential addresses were obtained from medical records and geocoded for 8017 (86%) of the 9334 study participants. Of these 8017 individuals, 7118 (76%) resided in North Carolina, and 5679 (61%) had a catheterization that occurred between 2003 and 2009.

Outcome Ascertainment

The Coronary Artery Disease (CAD) index was used to measure severity of coronary artery disease. The index ranges from 0 to 100 and is a risk indicator of events due to coronary atherosclerosis. A higher CAD index corresponds with an increased risk of ischemic events due to atherosclerosis. The CAD index takes into consideration the number of diseased coronary vessels (0-3), left anterior descending CAD, number of coronary vessels with 95% occlusion, 75% and 95% proximal left anterior descending coronary artery stenosis, and 75% and 95% left main coronary artery stenosis.

A binary measure of CAD was constructed and individuals with a CAD index >23 represent a population with at least one hemodynamically significant lesion (>75% luminal stenosis) in one epicardial coronary artery. We additionally assessed whether participants experienced an MI within a year prior to their catheterization. Participants were considered to be cases for the MI analyses if they had a documented MI in their medical records within a year prior to their catheterization visit.

Exposure assessment

We used patient addresses for the year prior to their most recent catheterization date. Patients' geocoded addresses were matched to the nearest EPA air quality monitor, 2000 census tract location (for CMAQ fused estimates), and centroid of the nearest 10km and 1km grid locations. $PM_{2.5}$ and ozone predictions were averaged for the year prior to each patient's most recent catheterization date. $PM_{2.5}$ averages represent yearly averages, while ozone averages represent individual averages from April to October (or during the ozone season). Some participants underwent multiple catheterization events during the study period. For those individuals the most recent catheterization visit was linked with exposure data.

Four different exposure assignment approaches were used: data from central site air quality monitors, CMAQ-fused predictions at the census tract level, satellite-based predictions at a 10km spatial resolution, and satellite-based hybrid predictions at a 1km spatial resolution. Satellite-based 10km predictions were only available for $PM_{2.5}$, while the rest of the exposure metrics were available for both $PM_{2.5}$ and ozone.

EPA central site monitored data

$PM_{2.5}$ and ozone monitored data were obtained from the Environmental Protection Agency's Air Quality System Data Mart for the years 2002 to 2009 for the state of North Carolina (EPA 2016a). We used the closest monitor to each participant's residence without a distance cutoff. Monitored data was collected as 24-hour averages for $PM_{2.5}$ and daily maximum 8-hour averages for ozone. This network of monitors collect data on $PM_{2.5}$ either daily or every 1 in 3 days. Therefore, $PM_{2.5}$ monitors were considered to have complete data if they had available data for 121 days of the year. Monitors were excluded if they had >25% missing data, or were missing data for an entire month. Ozone data was available daily from April to October for the state of North Carolina.

CMAQ-Fused Data

Community Multi-scale Air Quality (CMAQ) models combine input from a meteorological model and an emissions model with simulation of chemical and physical processes to describe pollutant transformation, transport and fate (EPA 2016b). A recently developed CMAQ model was created that uses a Bayesian space-time downscaler approach to combine CMAQ 12km gridded output with monitored data from NAMs and SLAMs across the US (EPA 2016c). The term "downscaler" refers to the scaling of the areal grid-cell CMAQ output to the point-level air monitoring data. Daily predictive surfaces of $PM_{2.5}$ (daily average in

$\mu g/m^3$) and ozone (daily 8-hr maximum in ppb) were used for the years 2002 through 2009 for the 2000 US census tract centroid locations. Predictions were not available on December 31st of any year because daily CMAQ output are not available on these days. More detailed information on this downscaler model has been described previously (Berrocal et al. 2010).

Satellite-based $PM_{2.5}$ modeled data

Satellite derived aerosol optical depth (AOD) measurements were additionally used to predict daily $PM_{2.5}$ concentration levels at a 10km and 1km spatial resolution for the state of North Carolina. AOD is a measure of the amount of light the particle prevents from travelling through the atmosphere. AOD are monitored using the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra and Aqua Satellites.

10km satellite-based PM2.5 models

Daily $PM_{2.5}$ concentrations were predicted at a 10 x 10 km spatial resolution for the state of North Carolina from 2002-2009 using recently developed statistical prediction models (Chudnovsky et al. 2012; Lee et al. 2011; Lee et al. 2012). These models estimate exposure using two main stages, including calibration with monitored data and then a cluster analysis approach. For the first stage, satellite-based AOD data were used to predict ground-level $PM_{2.5}$ concentrations for days when satellite data were available (Chudnovsky et al. 2012; Lee et al. 2011). A daily calibration approach using a mixed effects model was then applied to control for the inherent day-to-day variability in the AOD-$PM_{2.5}$ relationship. Next, a cluster analysis approach was applied that uses AOD and $PM_{2.5}$ ground monitoring data to predict $PM_{2.5}$ concentrations on days when satellite data are not available due to the presence of clouds or snow (Lee et al. 2012). More detailed information on the prediction model has been described previously (Chudnovsky et al. 2012; Lee et al. 2011; Lee et al. 2012).

1km hybrid satellite-based models

We also assessed $PM_{2.5}$ and ground-level ozone at a 1 km x 1 km spatial resolution from previously published and verified hybrid models (Qian Di et al. 2016; Qian Di et al. 2016). The hybrid prediction model incorporated satellite-based measurements (aerosol optical depth, absorbing aerosol index, ozone column measurements, etc.), simulation outputs from a chemical transport model (GEOS-Chem), land-use terms (population density, road density, NDVI, elevation etc.), meteorological variables (temperature, wind speed, humidity, etc.) and other ancillary data sets (e.g., climate types, vertical profile of $PM_{2.5}$ and ozone). The hybrid model used neural network to calibrate all the predictors to monitored $PM_{2.5}$ or ozone (N=1,928 for $PM_{2.5}$ and 1,877 for ozone). The model was trained and validated with ten-fold cross-validation. Cross-validation indicated good correlation between modeled air pollutants and monitored concentrations (R^2=0.84 for $PM_{2.5}$; R^2=0.76 for ozone at nationwide scale). The trained model made daily prediction of $PM_{2.5}$ and ozone at nationwide 1 km x 1 km grid cells from 2000 to 2012.

PM2.5 models

Ozone models

Figures 1 and 2 show the annual average 1km $PM_{2.5}$ ($\mu g/m^3$) and ozone (ppb) concentrations for the state of North Carolina for the years 2002-2009.

Confounders and effect measure modifiers

Covariates were chosen due to past associations with air pollution exposure and the cardiovascular outcomes. Covariates of interest include: age, sex, race/ethnicity (non-Hispanic White, African American, and other race/ethnicity), body mass index (BMI), smoking status, area level attained education, urban/ rural status, history of hypertension, and history of diabetes. Smoking status was defined by the Duke Institute for Clinical Cardiovascular Care as positive if participants smoked $\geq$ 10 cigarettes/day currently or had quit smoking $\geq$ 10 cigarettes/day within the past 5 years because of their cardiovascular disease, or as negative otherwise.

Data from the 2000 U.S. Census was used to characterize each participant's area level socioeconomic status (SES). Participants were assigned to block groups and census tracts based on their address at catheterization visit. Block-group level educational attainment was defined as the percentage of males and females in the block group without a high school education.

Rural Urban Commuting Codes at the census tract level were used to characterize each participant's urban/rural status. Urban census tracts were those defined as a metropolitan area core (primary flow within an urbanized area). Supplemental Figure 1 shows the spatial distribution of urban and rural census tracts throughout North Carolina.

Statistical Analyses

We first report descriptive statistics comparing the $PM_{2.5}$ and ozone exposure assignment approaches. We then compared exposure ranking of participants by categorizing individual annual average exposures into quartiles for each exposure assignment method and then assessed how many individuals changed exposure rankings as they moved from one exposure metric to another. Kappa statistics were additionally computed in order to assess consistency between the different exposure assignment methods. We additionally compared individual minimum and maximum differences across individuals to assess extent of variability between exposure models.

Finally, we examined correlations between each of the exposure assignment methods for $PM_{2.5}$ and ozone.

Logistic regression analysis was used to estimate odds ratios (OR) and 95% confidence intervals (CI) associated with a CAD index >23 or recent MI for each 1-$\mu g/m^3$ increase in annual average $PM_{2.5}$ and 5-ppb increase in annual average ozone. Models were adjusted for sex, race/ethnicity, smoking status, area level attained education, and urban/rural status. We assessed associations in single and multipollutant models. For the monitored, CMAQ, and 1km modeled estimates; multipollutant models were adjusted for the corresponding second pollutant values. Since no corresponding 10km exposure metric was available for ozone, the 10km $PM_{2.5}$ models were adjusted for 1km ozone levels. We were additionally interested in determining how pollutants may interact with each other. Therefore, we additionally assessed whether ozone levels modified $PM_{2.5}$ and CVD associations and whether $PM_{2.5}$ levels modified ozone associations.

An additional objective of the current paper was to assess whether urban/rural status modifies the association between long-term air pollution exposure and CAD. In order to accomplish this aim we included an interaction term between continuous levels of $PM_{2.5}$ for each of the exposure metrics and urban/rural status. We then compared these models with the main effects model without interaction terms. The Likelihood Ratio Test (LRT) was used to assess potential effect modification and a cutoff of $p<0.20$ was used to indicate presence of modification. Statistical analyses were performed using SAS version 9.3 (Cary, NC).

References

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Di Q, Kloog I, Koutrakis P, Lyapustin A, Wang Y, Schwartz J. 2016. Assessing pm2. 5 exposures with high spatiotemporal resolution across the continental united states. Environmental science & technology 50:4712-4721.

Di Q, Rowland S, P. K, Schwartz JD, (): , DOI:. 2016. A hybrid model for spatially and temporally resolved ozone exposures in the continental united states. Journal of the Air & Waste Management Association in press.

EPA. 2016a. Air quality system data mart Available: http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html.

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Lee HJ, Coull BA, Bell ML, Koutrakis P. 2012. Use of satellite-based aerosol optical depth and spatial clustering to predict ambient pm2.5 concentrations. Environmental research 118:8-15.

To: McGuinn, Laura[lmcguinn@live.unc.edu]
Cc: Devlin, Robert[Devlin.Robert@epa.gov]
From: Qian Di
Sent: Mon 11/14/2016 8:19:06 PM
Subject: Re: Help with 1km methods section

Great. Glad to hear that. You can send me the draft version and I can add my stuff.
Thanks,
Qian

On Mon, Nov 14, 2016 at 3:09 PM, McGuinn, Laura <lmcguinn@live.unc.edu> wrote:

> Hi Qian,
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> Bob and I are nearing the completion of our analyses using your 1km PM2.5 and ozone data and were wondering if we could get your help with writing the methods section for these data? Alternatively, I think I have a copy of both of your papers for the data, so can start on this section, and then you can edit as needed? If it would help, I can send you a draft of the methods section for the paper?
>
> Thanks,
> Laura

--
Di, Qian (QD) 1-814-777-8202

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Harvard T.H. Chan School of Public Health

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Keck School of Medicine of USC

DEPARTMENT OF PREVENTIVE MEDICINE
Duncan C. Thomas
Division of Biostatistics, Professor and Director
Verna R. Richter Chair in Cancer Research

June 19, 2017

Dr. Petros Koutrakis
Exposure, Epidemiology & Risk Program
Harvard T. H. Chan School of Public Health
Landmark Center West, Room 410-a
401 Park Drive
Boston, MA 02215

Dear Petros,

Many thanks again for hosting an outstanding inaugural meeting of the Scientific Advisory Committee (SAC) for your new EPA Air, Climate and Energy (ACE) Center. The presentations were interesting with stimulating discussions, the poster sessions were a great complement, giving us the opportunity to get into the details with your junior team members, and the overall organization went like clockwork. The SAC members all felt like we learned quite a bit from the meeting, and hope that you found our feedback equally helpful.

Overall, the SAC feels that your Center is very responsive to all of the EPA's Research Questions, with each project addressing most if not all of them in different but overlapping ways. The caliber of the science being done is excellent overall, the research team is superb, and the productivity is great. We particularly like the way in which graduate students and postdocs are integrated into the research team, in many cases driving some of the most exciting developments, and getting superb training in the process. Overall, we feel that the various projects are well integrated into a comprehensive research program, although there are specific areas where we feel communication could be enhanced.

We thought it would be helpful to begin by highlighting some of the aspects of the Center's work that we found particularly noteworthy. Many of the following bullet points represent worthy goals that the Center is only beginning to attack, but we want to commend you for prioritizing them; others are things that are already bearing fruit.

- The focus on policy implications, in particular "accountability" as a goal and the use of causal inference techniques to address it. Systematic analysis of the linkage among emission reductions, air pollution levels, and associated health impacts are being conducted within the accountability framework, which is particularly relevant given the substantial improvement in air quality in the eastern US since 2000.
- The focus on assessing the effects of air pollution at low concentrations, including those below the current regulatory standards. The epidemiological research of this center is looking specifically at concentration-response functions at low levels; we commend and encourage this. The researchers also are testing for nonlinearities in the concentration-response functions; we commend and encourage that topic as well.

University of Southern California
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- The focus on the effects of climate change, with particular emphasis on assessing the air pollution and health effects of climate change using robust methods that are valid under a broad array of realistic climate models.
- Exploiting the different scales of spatial and temporal variation (e.g., national, regional, urban, local; daily, seasonal, annual) to build comprehensive models and assess the different exposure-outcome associations at the different levels. Particularly notable here is the work on dealing with interference and cross-state impacts.
- The integration of multiple types of data through novel techniques like neural networks with the ultimate goal of combining mechanistic and statistical approaches.
- Thorough evaluation of confounders and modifiers; novel techniques for variable selection amongst the set of available variables were described, which are already yielding some valuable insights, such as the effect of government assistance programs beyond socioeconomic and other potential confounders.
- The careful uncertainty analysis at each stage and propagation of uncertainties across stages; the former is already well advanced, the latter is recognized as a long-term goal, but one where methodological approaches are still under development.

Now to some overarching points:

There is a lot of great work going on in the Center that will improve our understanding of air pollution and related health effects based on both recent air quality and on projections into the future. This includes the development of novel approaches to characterize ambient pollutant concentrations, including: relatively low concentrations in locations where air quality monitoring data are not available; the application of causal modeling approaches to probe the relationships between air pollution and health, particularly in locations with relatively low pollutant concentrations; and the development of approaches to project impacts of future air quality scenarios.

There is an expectation for ACE centers to provide plausible and innovative solutions. To achieve this, the implications of the research results will need to be communicated broadly, including to stakeholders outside of the research community. We encourage the Center to put results in a context that can be best understood by decision makers and to work on methods that make this possible. Some examples of questions that could be of interest to such stakeholder groups and may require development of new methods or modification of current research methods include: How much more or faster would the incidence of asthma have increased if air pollution had not decreased? What would be the health benefits of reducing ambient $PM_{2.5}$ concentrations below the NAAQS to lower concentrations, such as from 8 to 6 $\mu g/m^3$? What would be the co-benefit for air quality management if multiple pollutants (e.g., O_3, NO_x, VOCs, NH_3) were analyzed along with PM? While we recognize that the Center already has highly ambitious specific aims, these and related questions may be incorporated into the existing research to the degree feasible.

The SAC would also like to see greater testing and sensitivity analysis of the models. The Center involves development of innovative new models. While the first year has been highly productive for the development of these novel methods, we suggest that the next year include substantial efforts devoted to rigorous approaches to evaluate the models; for example: What are the ways in which the model might not work? How would one investigate to see if and when the model works or doesn't work? Can independent data sets be used to understand model strengths or weaknesses?

Here is one illustrative example, but we hope you will consider this comment with regard to all of the models developed, not just this specific example: In the empirical model for emissions, the estimates for secondary formation are based on only one variable (temperature), which is a large assumption. One should test whether estimates for primary vs. secondary PM are realistic. Emissions from specific power plants are well known and easy to look up; you could compare the emission estimates for power plants to CEMS data. Again, we hope that the researchers will bring self-skepticism to the modeling in general and will more rigorously test the models and tools they develop.

Now to some specifics:

Accountability

The Center has already made important advances in characterizing air quality at finer spatial scales and across a wider range of areas than has been possible using only the regulatory monitoring networks. This includes improved characterization of $PM_{2.5}$ concentrations outside of urban areas, where ambient monitoring data are often not available and where concentrations can be relatively low. These advances in air quality characterization, together with the large cohorts and other health datasets available to the Center, present an opportunity to evaluate the public health impacts of improving air quality at low pollutant concentrations. In particular, an important question that could be addressed is whether the anticipated health benefits of improving air quality have occurred in locations with relatively low starting concentrations of key air pollutants (e.g., below current standards).

The Center could also think about whether it is feasible to link long-term changes in public health with long-term improvements in air quality based on their decomposed $PM_{2.5}$ surfaces at different spatial scales. By doing this, they might be able to address questions regarding the relative public health impacts of reducing pollution from regional sources versus local sources.

Potential for confounding and effect modification

The work characterizing the potential for differential confounding over the distribution of ambient $PM_{2.5}$ concentrations is very important, and has the potential to improve our understanding of health effects. To the extent feasible, when evaluating associations with $PM_{2.5}$ (or O_3, NO_2, other pollutants), we encourage the Center to also consider the potential for confounding and/or effect modification by the broader pollutant mixture. If data are available, it would also be valuable to consider the potential confounding and modifying effects of non-pollutant stressors such as temperature and noise (the former has already been evaluated in some of the work presented and this should be encouraged).

PM composition and heterogeneity in PM risks

PM composition is being investigated as a potential contributor to the observed heterogeneity in the risks of short-term $PM_{2.5}$ exposures. In addition to evaluating associations between mortality and individual components, which seems to be a focus of ongoing work, it could also be useful to examine PM composition as a potential modifier of PM associations. It may be that PM risks are larger in areas where certain mixtures of components (from certain sources) dominate and smaller in other areas, potentially explaining some of the heterogeneity in PM effects. In addition, to the extent the Center's fused PM surfaces improve estimates of population exposures, they could also provide insight into the issue of heterogeneity in the risks of PM exposures (e.g., by reducing exposure measurement error, particularly for populations farther from monitors).

Exposure characterization

The Center's more refined air quality surfaces represent an important advance. At this point, it is not clear the degree to which these refined surfaces allow improved exposure characterizations in various populations; for example, some populations may receive substantial portions of their exposures away from home address/zip code. Therefore, additional efforts to evaluate mobility patterns in various populations could be valuable (e.g., expanding upon the ongoing work using cell phone locations and work estimating the effect of roads on indoor PM concentrations). Also, it would be helpful if the Harvard/MIT Center could work with the other ACE Centers to provide guidance on emissions management decisions that are needed at the local, urban, state-level, regional, or national levels to help reduce adverse impacts on human health.

In addition to these general points, the SAC offers a few **minor points**:

- As a matter of good process, the methodologies need to be documented.
- Local vs regional-scale definitions are needed to better explain the zone of representation at the receptor (e.g., monitoring site). Different terminology may be necessary in different parts of the project, but this should be recognized and done consciously.
- The high-frequency versus low-frequency analyses were interesting and useful. We think it would also be interesting to look at health effects and concentration-response functions for urban versus rural areas, and for primary PM versus secondary PM.
- The regression models being developed are generally based on the unit of analysis in the underlying data—for example, the monitoring data (1 observation = 1 monitor), or land area (e.g., 1 observation = 1 cell = 1 square kilometer). We suggest doing the regressions and model development on a population-weighted basis (e.g., 1 observation = 1000 people). That approach might yield models that are more useful for exposures than land area –weighted models.

To conclude, we offer a few **recommendations**:

- This esteemed ACE team has exhibited high productivity and a high level of sophistication regarding their modeling ability. The SAC would like Harvard and MIT teams to have better coordination. One approach might be to have the graduate students and postdocs communicate more. Recognizing that the PI's are generally very busy individuals, one way to strengthen the current threads and potentially develop additional threads without greatly burdening the PIs might be to have routine (say monthly or so during the first year) meetings between the Center graduate students and post-docs where a junior member from each project presents and attendance by the other students/post-docs is highly encouraged and may also be attended by PIs when available. In addition to the benefits to the Center, this will also be very beneficial to the students/post-docs.
- Of course, it is not just the Harvard and MIT graduate students and post-docs that need to communicate more, there is also a need for the fifth project to be more closely integrated

with projects 1 through 4. Right now, project 5 seems like it is on its own, focusing on statistical modeling of climate effects and projecting climate using advanced models. There does not appear to be much effort to link it to the other , at least at this early stage. The PI and students at MIT were not even aware of the nature of the accountability work being done by Harvard under project 4, and certainly had not integrated thinking about estimating exposure and health effects using results and insights from projects 1, 2, and 3. The project team needs to have a plan for how project 5, which is really the place where synthesis across the projects can take place, is going to accomplish the synthesis and quantify future health impacts in a way that builds on all of the exposure and health research.

- There are obvious threads within and between the projects, but those threads should be strengthened. There was some concern that researchers were unaware of other related researcher projects in the Center. Some specific examples of gaps in communication between communities or places where there should be more communication include
    - Definition of primary vs. secondary PM, especially for organic aerosol. Atmospheric chemistry community may have a different perspective than top-down estimates.
    - Derivation of $PM_{2.5}$ from AOD. GEOS-Chem vertical profiles could inform translation of AOD to surface $PM_{2.5}$. Is previous experience being adequately leveraged?
    - How do bottom-up (NEI, GEOS-Chem community) vs. top-down (PEIRS) emission inventories compare?
    - Incorporation of chemistry and multiple pollutants in source attribution (e.g., SO_2 as a proxy for coal combustion ignores chemistry as well as contribution of NO_x to ammonium nitrate aerosol formation).
- Challenge and verify model assumptions, for example, primary vs. secondary $PM_{2.5}$ attribution and propagation of uncertainty. Uncertainty is always a difficult subject, but very important nonetheless. Each project should try to quantify the uncertainties, how they propagate, and identify which are the major uncertainties of concern. This is true throughout the projects. Some have it built in more explicitly, but all should address this in such a way that other researchers readily understand what levels are likely involved in using the outputs of the Center.
- We encourage the Center to voluntarily share data beyond what is required by the EPA Centers' data sharing policy as much as reasonably possible via supporting information, code repositories, etc., as this will facilitate transfer of information to the scientific community. We thank the Center for already taking steps to use resources such as GitHub for this purpose. If data cannot be directly shared by the Center, code to process and analyze data obtained directly from the owners, along with documentation of the version of the data used so that others may request access from the owners and subsequently reproduce analyses, should be provided. "Transferability" of tools/techniques/data sets to regulators would also be useful, where these can be done in a relatively straightforward manner and where resources and data privacy allows. Well-documented methods and data sets that others may be able to use would be an important output of the centers. The Center is already leading the way in these types of efforts, and we encourage these endeavors.
- We understand that there are plans to start organizing cross-center collaborations during the second year. The SAC feels this will be particularly valuable, with potentially a number of different working groups being established on various methodological and substantive topics. We see several potential opportunities for this center to work with the other centers

and understand that EPA funding is available specifically for this activity. We share the following ideas, for the researchers' consideration:

- The research by Zigler and Selin could usefully employ reduced-form models and source-receptor matrices from CMU/UMN/UW/EPA/ORD;
- The Yale/JHU Center is studying how to interface with policy-makers, and how to message research findings; researchers at Harvard/MIT should incorporate those insights in how they interpret and make use of their findings;
- Like the Harvard/MIT Center, the CMU/UMN/UW center is also developing high spatial resolution estimates of air pollution concentrations. We encourage the centers to compare results;
- All three centers are generating concentration-response functions. We hope the centers will, at some point, compare those findings.

- Look to the decision makers (e.g., states) to make your work more relevant and impactful earlier on. The committee encourages you to take the opportunity to involve not only SAC member Paul Miller as a state policy liaison, but others in other regions (e.g., the Southeast, California).
- While we recognize the importance of the $PM_{2.5}$ work, we encourage work on other air pollutants that have timely relevance for decision makers, such as ozone. Source attribution techniques being developed for $PM_{2.5}$, if applicable to ozone precursors (specifically NO_x), would be extremely useful now. The Center could also address other policy-relevant issues such as visibility. All constituents of $PM_{2.5}$ affect visibility, hence source apportionment techniques for exposure assessments may have application to this as well. Visibility planning policies could also lead to near-term reductions to $PM_{2.5}$, thereby improving public health and contributing to regulatory compliance.

Again, thanks for a stimulating meeting, congratulations on all you've accomplished already and your lofty goals for the future, and we very much look forward to seeing you again next year!

Sincerely,

Duncan C Thomas

Duncan C. Thomas, PhD
Professor of Biostatistics
Verna Richter Chair in Cancer Research
SAC Chairman

cc: SAC members Michelle Bell, Judy Chow, Susan Collet, Robert Devlin, Amy Herring, Bryan Hubbell, Scott Jenkins, Julian Marshall, Paul Miller, Pye Havala, ST Rao, Ted Russell

To: Qian Di[qiandi@mail.harvard.edu]; McGuinn, Laura[lmcguinn@live.unc.edu]
From: Devlin, Robert
Sent: Wed 11/23/2016 1:15:12 PM
Subject: RE: Help with 1km methods section

Thanks, Qian. Would you be able to send us a pdf of the reference you cite below?

From: Qian Di [mailto:qiandi@mail.harvard.edu]
Sent: Tuesday, November 22, 2016 9:09 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>; McGuinn, Laura <lmcguinn@live.unc.edu>
Subject: Re: Help with 1km methods section

Hi Laura,

Here is the paragraph that I added. Please let me know if there is anything needed.

--- Robert,

The ozone concentrations were from a hybrid model, which takes GEOS-Chem simulation outputs as a one input variable. Other variables go into the hybrid model as well, including meteorological variables, satellite measurements and other variables. The details were articulated in the following reference:

Di, Q., Rowland, S., Koutrakis, P. and Schwartz, J., 2016. A Hybrid Model for Spatially and Temporally Resolved Ozone Exposures in the Continental United States. *Journal of the Air & Waste Management Association*, (just-accepted).

Qian

On Tue, Nov 15, 2016 at 11:41 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:

Qian:

I have a question. Do the ozone values from the hybrid 1km model come from GEOS-Chem or somewhere else?

From: Qian Di [mailto:qiandi@mail.harvard.edu]
Sent: Monday, November 14, 2016 3:19 PM
To: McGuinn, Laura <lmcguinn@live.unc.edu>
Cc: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Help with 1km methods section

Great. Glad to hear that. You can send me the draft version and I can add my stuff.

Thanks,

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Hi Qian,

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Thanks,

Laura

--

Di, Qian (QD) 1-814-777-8202

Doctoral Student
Department of Environmental Health
Harvard T.H. Chan School of Public Health

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Subject: RE: Help with 1km methods section

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哈佛大学公共卫生学院环境健康系博士生

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Devlin, Robert
Sent: Mon 3/27/2017 8:17:15 PM
Subject: RE: Paper submission to NEJM

I'll get you something in the next few days. Right now I'm engrossed with helping to fight back the proposed cuts to EPA.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 1:49 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: RE: Paper submission to NEJM

Let me know what do you think when you get a chance to read it

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 12:57 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Paper submission to NEJM

I got it.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 11:53 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>; Devlin, Robert <Devlin.Robert@epa.gov>
Subject: FW: Paper submission to NEJM

Just let me know you got it

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Devlin, Robert
Sent: Mon 3/27/2017 4:56:50 PM
Subject: RE: Paper submission to NEJM

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
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To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Devlin, Robert
Sent: Mon 3/27/2017 3:50:19 PM
Subject: RE: Manuscript to send to co-authors

Sure, I be happy to look at the paper. And I won't share it with anyone else.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 11:32 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: RE: Manuscript to send to co-authors

Hi Bob I agree, but I just wanted to give you my take on this.

I believe that too much massage of data does not really help and sometimes can be counter productive

A month ago we submitted a paper to NEJM which apparently is under review. Of course I do not know what the outcome may be. However, I am very interested in your opinion. If you think that you can keep this confidential I would like to send you a copy. Note that we are writing a follow up paper that further substantiates this hypothesis by using actual measurements of gross beta radiation as a surrogate of alpha particle exposures.

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Manuscript to send to co-authors

Thanks for the comments Petros. These models are not really in my bailiwick so I'm not confident we've set the right tone in the discussion. As you point out, its also complicated with so many co-authors. If I dis the CMAQ models Ted and the EPA will not be happy.

Were you surprised that your “simple’ 10km model performed as well as the newer 1 km model with all the extras like Geochem?

Also, we’re now completing a similar comparison of the various models associating acute PM exposure with health effects.

See you in May.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Saturday, March 25, 2017 7:25 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Alexandra Chudnovsky <achudnov@post.tau.ac.il>
Subject: RE: Manuscript to send to co-authors

Bob I went through the paper. It is a very nice paper with interesting results.

The conclusion to me is just use the satellite data with calibrations. No need for CMQ, GEOCHEM and other time consuming models.

This is very important in order to have more applications of remote sensing. If the procedures are simple and easy to follow then many epi researchers will use them. If the procedures can be applied only by a small group then the applications will be very limited.

Another important conclusion is that results based on monitoring data were not that bad.

The conclusions are kind neutral and I understand why. Obviously different authors have different opinions. It is a pity!!

Finally, can we acknowledge the Harvard center Alice can send you the information.

There is not attachment

Good luck

From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 20, 2017 10:52 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>
Subject: FW: Manuscript to send to co-authors

Attached is manuscript we have prepared that describes associations between two adverse outcomes and 5 different approaches to estimate PM2.5 values. Please look it over and make sure that we've accurately portrayed the various exposure models.

I'm not sure I have the addresses of Alexandra or Qian, so please forward this to them also.

We're under a lot of pressure to get this submitted ASAP so we need your comments within the next two weeks if possible. If we don't hear back we'll assume that you are OK with the paper as is.

From: McGuinn, Laura [mailto:lmcguinn@live.unc.edu]
Sent: Monday, March 20, 2017 9:30 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Manuscript to send to co-authors

Sorry, here's the correct manuscript and supplemental material to send out, disregard my previous email.

Thanks,

Laura

From: McGuinn, Laura
Sent: Sunday, March 19, 2017 10:44 AM
To: Devlin, Robert
Subject: Manuscript to send to co-authors

Here's the most up to date version of the manuscript (and supplemental tables and figures) to send to the co-authors for feedback.

Thanks,

Laura

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Devlin, Robert
Sent: Mon 3/27/2017 2:18:39 PM
Subject: RE: Manuscript to send to co-authors

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From: Devlin, Robert [mailto:Devlin.Robert@epa.gov]
Sent: Monday, March 20, 2017 10:52 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Schwartz, Joel <jschwrtz@hsph.harvard.edu>
Cc: McGuinn, Laura <lmcguinn@live.unc.edu>
Subject: FW: Manuscript to send to co-authors

Attached is manuscript we have prepared that describes associations between two adverse outcomes and 5 different approaches to estimate PM2.5 values. Please look it over and make sure that we've accurately portrayed the various exposure models.

I'm not sure I have the addresses of Alexandra or Qian, so please forward this to them also.

We're under a lot of pressure to get this submitted ASAP so we need your comments within the next two weeks if possible. If we don't hear back we'll assume that you are OK with the paper as is.

From: McGuinn, Laura [mailto:lmcguinn@live.unc.edu]
Sent: Monday, March 20, 2017 9:30 AM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Manuscript to send to co-authors

Sorry, here's the correct manuscript and supplemental material to send out, disregard my previous email.

Thanks,

Laura

From: McGuinn, Laura
Sent: Sunday, March 19, 2017 10:44 AM
To: Devlin, Robert
Subject: Manuscript to send to co-authors

Here's the most up to date version of the manuscript (and supplemental tables and figures) to send to the co-authors for feedback.

Thanks,

Laura

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Devlin, Robert
Sent: Thur 3/23/2017 1:18:43 PM
Subject: RE: Manuscript to send to co-authors

I'm looking forward to being there.

-----Original Message-----
From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, March 22, 2017 8:24 PM
To: Devlin, Robert <Devlin.Robert@epa.gov>
Subject: Re: Manuscript to send to co-authors

Bob nice to hear from you
I will try to take a look asap
Hope to get a chance to talk to you in may during your Boston visit

Sent from my iPhone

> On Mar 20, 2017, at 10:52 AM, Devlin, Robert <Devlin.Robert@epa.gov> wrote:
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> Thanks,
>
> Laura
> <20170316_CATHGEN Exp Metrics.docx>
> <20170319_Supplemental Material_CATHGEN Exp Metrics.docx>

To: petros <petros@hsph.harvard.edu>[petros@hsph.harvard.edu]; Joel schwartz[joel@hsph.harvard.edu]
Cc: McGuinn, Laura[lmcguinn@live.unc.edu]
From: Devlin, Robert
Sent: Mon 3/20/2017 2:52:09 PM
Subject: FW: Manuscript to send to co-authors
20170316_CATHGEN Exp Metrics.docx
20170319_Supplemental Material_CATHGEN Exp Metrics.docx

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Thanks,

Laura

Long Term Air Pollution Exposure and Cardiovascular Disease: Comparison of Exposure Assessment Methods

Laura A. McGuinn[1], Cavin Ward-Caviness[2], Alexandra Schneider[3], Qian Di[4], Alexandra Chudnovsky[4], Joel Schwartz[4], Petros Koutrakis[4], Armistead G. Russell[5], William Kraus[6], Elizabeth Hauser[6], Lucas M. Neas[2], Wayne Cascio[2], David Diaz-Sanchez[2], Robert B. Devlin[2]

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Abstract

Cardiovascular events have been linked with $PM_{2.5}$ exposure, though most studies have used data from air quality monitors. Modeled $PM_{2.5}$ predictions may more accurately predict exposure concentrations over monitored data, however few studies have compared results across methods. We utilized a cohort of 5679 patients who had undergone a cardiac catheterization between 2002-2009 and resided in NC. Exposure to $PM_{2.5}$ was estimated using data from air quality monitors, CMAQ fused models at the census tract and 12km spatial resolution, and satellite-based models at a 10 and 1km resolution. Predictions were averaged for the year prior to catheterization. The coronary artery disease (CAD) index was used to measure severity of CAD, and individuals with an index >23 were considered cases. Logistic regression was used to model odds of having CAD or a myocardial infarction (MI) with each 1-unit (μg/m3) increase in annual average $PM_{2.5}$, adjusting for sex, race, smoking status, socioeconomic and urban/rural status. We found elevated odds for CAD for the monitored (OR=1.04, 95%CI:0.99-1.10), census tract CMAQ (OR=1.07, 95%CI:1.02-1.13), 12km CMAQ (OR=1.10, 95%CI:1.04-1.17), 10-km (OR=1.13, 95%CI: 1.06-1.21), and 1km satellite-based $PM_{2.5}$ models (OR=1.09, 95%CI:1.03-1.15). Long-term $PM_{2.5}$ was associated with CAD for both modeled and monitored $PM_{2.5}$ data.

INTRODUCTION

Historically, epidemiology studies that link fine particulate matter ($PM_{2.5}$) exposure with adverse cardiopulmonary outcomes have used data from central site air quality monitors to characterize $PM_{2.5}$ exposure. These studies assume measurements at a single site are representative of air quality over a larger area. Further, monitoring networks are usually placed in highly populated urban areas, thus the measurements may not accurately reflect exposure for rural populations. Central site monitoring networks are additionally limited temporally since, depending on the monitoring site, $PM_{2.5}$ measurements may be collected every day, 1 in 3 days, or even 1 in 6 days.

More sophisticated modeling approaches are emerging that may better characterize air pollution exposure and overcome some of these temporal and spatial limitations. Specifically, models have increasingly started to incorporate remote sensing and atmospheric chemistry data to help characterize $PM_{2.5}$ exposure in epidemiological studies. The Community Multiscale Air Quality (CMAQ) is one widely used and publicly available modeling system that combines information from a meteorological model and an emissions model with simulation of chemical and physical processes to predicts air pollutant concentrations at 12km grids throughout the US. A hierarchical Bayesian model was recently developed that fuses 12km CMAQ data with monitored data with output at the census tract level.[1] Further, another CMAQ-based emissions model was recently developed that fuses CMAQ data with monitored data with output at a 12km spatial resolution. Several recent epidemiological studies have used these fused models to characterize $PM_{2.5}$ exposure in relation to birth outcomes[2, 3] asthma symptoms, [4, 5] and pediatric emergency visits.[6]

Recent epidemiological studies have additionally incorporated remote sensing information into their air pollution models in order to help characterize exposure. These satellite-based air pollution models often calibrate the aerosol optical depth (AOD) retrievals with data from ground monitoring stations in order to address missing data due to cloud coverage and help model fit. Specifically, several recent epidemiological studies have used AOD retrievals calibrated with monitoring data at a 10km spatial resolution.[7, 8] Hyder et al.[9] used satellite-based estimates developed by Lee et al.[7] to compare the results from monitored and 10km satellite-based models in relation to birth outcomes and found that the satellite based models calibrated with monitoring data had overall better fit compared to the monitored data alone. Further, Kloog et al.[10] calibrated AOD retrievals with monitored data, but additionally incorporated land use terms and meteorological variables. Studies have used these estimates to assess associations with myocardial infarctions, mortality, and birth outcomes.[11-13] Recent satellite-based estimates have been developed at finer spatial resolutions using the multiangle implementation of atmospheric correction (MAIAC) AOD retrieval algorithm.[14, 15] Several of these models have used a hybrid approach where they additionally incorporated information on land use terms and data from chemical transport models. Jerrett et al.[16] recently compared results from several $PM_{2.5}$ models and found the 1km satellite based models that were calibrated with ground based measurements and incorporated land use terms to have overall better model fit than remote sensing data alone.

In the current paper, we use data from five different exposure assignment methods to assess the association between long term $PM_{2.5}$ exposure and adverse cardiovascular outcomes. First, we use direct measurements from central site air quality monitors, a common approach in many epidemiological studies. Next, we use data from CMAQ fused models at the census tract level and 12km spatial resolution. These models use CMAQ emissions based estimates calibrated with monitoring data to improve model fit. We additionally compare results from a

10km satellite-based model calibrated with monitoring data. Finally, we compare results using data from a 1km satellite-based model, to assess associations at a finer spatial resolution. The 1km satellite-based model is calibrated with monitored data, and additionally incorporates land use terms, meteorological variables, and incorporates information from the GEOS-Chem chemical transport model.

Using data from these five sources, we assessed associations between long-term $PM_{2.5}$ exposure and measures of cardiovascular disease in a cohort of cardiac catheterization patients residing in North Carolina. Specific measures of cardiovascular disease include the coronary artery disease (CAD) severity index and measures of myocardial infarction (MI). We evaluate how robust the associations are to $PM_{2.5}$ exposure estimates from the five different sources. The study additionally aims to assess if the $PM_{2.5}$-CAD association differs by urban/rural status across the different exposure assignment approaches.

MATERIALS AND METHODS

Study Population

Study participants came from the CATHeterization GENetics (CATHGEN) study, a large cohort of 9334 participants primarily from North Carolina presenting to the Duke University Medical Center Cardiac Catheterization Clinic between 2001 and 2011.[17] Participants underwent a cardiac catheterization and coronary angiography in order to diagnose and treat coronary artery disease. Clinical information was obtained from an intake questionnaire at the time of catheterization as well as medical records. All subjects received and signed informed consent forms prior to enrollment, and CATHGEN has been approved by and follows all Duke University Institutional Review Board policies.

Exposure data for the 10km satellite-based $PM_{2.5}$ estimates were available from January 1, 2002 through December 31, 2009, thus exposure data for all exposure assignment approaches were restricted to this timeframe for comparability across exposure metrics. A yearly average was created for each participant and exposure metric using the 365 days of exposure prior to each participant's catheterization date. Therefore, patients were included in the current analysis if they resided in North Carolina and their catheterization procedure was performed from January 1, 2003 through December 31, 2009. Residential addresses were obtained from medical records and geocoded for 8017 (86%) of the 9334 study participants. Of these 8017 individuals, 7118 (76%) resided in North Carolina, and 5679 (61%) had a catheterization that occurred between 2003 and 2009.

Outcome Ascertainment

The Coronary Artery Disease (CAD) index was used to measure severity of coronary artery disease.[18] The index ranges from 0 to 100 and is a risk indicator of events due to coronary atherosclerosis. A higher CAD index corresponds with an increased risk of ischemic events due to atherosclerosis. The CAD index takes into consideration the number of diseased coronary vessels (0-3), left anterior descending CAD, number of coronary vessels with 95% occlusion, 75% and 95% proximal left anterior descending coronary artery stenosis, and 75% and 95% left main coronary artery stenosis.

A binary measure of CAD was constructed and individuals with a CAD index >23 represent a population with at least one hemodynamically significant lesion (>75% luminal stenosis) in one epicardial coronary artery. There were 610 individuals who underwent a therapeutic intervention and thus did not have a full catheterization, therefore the total sample size for the CAD index outcome is 5,069 participants. We additionally assessed whether participants experienced an MI within a year prior to their catheterization. Participants were considered to be cases for the MI analyses if they had a documented MI in their medical records within a year prior to their catheterization visit. There were 5,679 participants who had full MI outcome information available.

Exposure Assessment

Five different exposure assignment approaches were used: data from a) central site air quality monitors, CMAQ fused predictions at the b) census tract level and c) 12km spatial resolution, and satellite-based predictions at a d) 10km and e) 1km spatial resolution. We used patient addresses for the year prior to their most recent catheterization date. Patients' geocoded addresses were matched to the nearest EPA air quality monitor, 2000 census tract location (for EPA-CMAQ estimates), and centroid of the nearest 12km, 10km, and 1km grid locations. $PM_{2.5}$ predictions were averaged for the year prior to each patient's most recent catheterization date. Some participants underwent multiple catheterization events during the study period. For those individuals the most recent catheterization visit was linked with exposure data.

EPA Central Site Monitored Data

$PM_{2.5}$ monitored data (daily average in $\mu g/m^3$) were obtained from the Environmental Protection Agency's (EPA) Air Quality System (AQS) Data Mart for the years 2002 to 2009 for the state of North Carolina.[19] We used the closest air quality monitor to each participant's residence without a distance cutoff. This network of monitors collect data on $PM_{2.5}$ either daily or every 1 in 3 days. Therefore, $PM_{2.5}$ monitors were considered to have complete data if they had available data for 121 days of the year. Monitors were excluded if they had >25% missing data, or were missing data for an entire month.

EPA CMAQ Downscaler Model

Community Multi-scale Air Quality models combine input from a meteorological model and an emissions model with simulation of chemical and physical processes to describe pollutant transformation, transport and fate.[20] A recently developed CMAQ model was created that uses a Bayesian space-time downscaler approach to combine CMAQ 12km gridded output with monitored data across the US.[21] The term "downscaler" refers to the scaling of the areal grid-cell CMAQ output to the point-level air monitoring data, with resulting outputs at the census tract level. Daily predictive surfaces of $PM_{2.5}$ (daily average in $\mu g/m^3$) were used for the years 2002 through 2009 for the 2000 US census tract centroid locations. More detailed information on this downscaler model has been described previously.[1]

Georgia Tech CMAQ-Observation Data Fusion Model

CMAQ-Observation Data Fusion (Data-Fusion or DF) is another method that combines observations and chemical transport model air quality fields.[22] Again, the Community Multiscale Air Quality (CMAQ) model is the chemical transport model used. The method first krigs the observations to develop one estimate of pollutant concentrations across the domain. Separately, CMAQ fields (in this case using 12x12km resolution results) are scaled to spatially and temporally better align with observations, providing a second set of fields. The two fields are then merged into a combined field based on correlation analysis. The resulting field captures the spatially more detailed information provided by the air quality model, as well as the coarser scale spatial and fine scale temporal information from the observations. The approach was applied from 2002 to 2010 over North Carolina (USA) to develop the spatiotemporal fields of 24hr-average $PM_{2.5}$ concentrations used here, but has also been used to provide $PM_{2.5}$ species and gaseous pollutant concentrations as well.[23]

Satellite-based Models

Satellite derived aerosol optical depth measurements were additionally used to predict daily $PM_{2.5}$ concentration levels at a 10km and 1km spatial resolution for the state of North Carolina. AOD is a measure of the amount of light the particle prevents from travelling through the atmosphere. AOD are monitored using the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra and Aqua Satellites.

10km Satellite-based Model

Daily $PM_{2.5}$ concentrations were predicted at a 10x10km spatial resolution for the state of North Carolina from 2002-2009 using recently developed statistical prediction models.[7, 24, 25] These models estimate exposure using two main stages, including calibration with monitored data and then a cluster analysis approach. For the first stage, satellite-based AOD data were used to predict ground-level $PM_{2.5}$ concentrations for days when satellite data were available. A daily calibration approach using a mixed effects model was then applied to control for the inherent day-to-day variability in the AOD-$PM_{2.5}$ relationship. Next, a cluster analysis approach was applied that uses AOD and $PM_{2.5}$ ground monitoring data to predict $PM_{2.5}$ concentrations on days when satellite data are not available due to the presence of clouds or snow.[25] More detailed information on the prediction model has been described previously.[7, 24, 25]

1km Satellite-based Model

We also assessed $PM_{2.5}$ at a 1x1km spatial resolution from previously published and verified hybrid models.[14] The hybrid prediction model incorporated satellite-based measurements (aerosol optical depth, absorbing aerosol index), simulation outputs from a chemical transport model (GEOS-Chem), land-use terms (population density, road density, NDVI, elevation etc.), meteorological variables (temperature, wind speed, humidity, etc.) and other ancillary data sets (e.g., climate types, vertical profile of $PM_{2.5}$). The hybrid model used neural network to calibrate all the predictors to monitored $PM_{2.5}$. The model was trained and validated with ten-fold cross-validation. Cross-validation indicated good correlation between modeled air pollutants and monitored concentrations (R^2=0.84). More information on this model has been described previously.[14] Figure 1 shows the annual average 1km $PM_{2.5}$ (μg/m^3) concentrations for the state of North Carolina for the years 2002-2009. A description of each of the five exposure assessment options can be seen in Table 1.

Confounders and Effect Measure Modifiers

Covariates were chosen due to past associations with air pollution exposure and the cardiovascular outcomes. Covariates of interest include: age, sex, race/ethnicity (non-Hispanic White, African American, and other race/ethnicity), body mass index (BMI), smoking status, area level attained education, urban/ rural status, history of hypertension, and history of diabetes. Smoking status was defined by the Duke Institute for Clinical Cardiovascular Care as positive if participants smoked ≥ 10 cigarettes/day currently or had quit smoking ≥ 10 cigarettes/day within the past 5 years because of their cardiovascular disease, or as negative otherwise.

Data from the 2000 U.S. Census was used to characterize each participant's area level socioeconomic status (SES).[26] Participants were assigned to block groups and census tracts based on their address at catheterization visit. Block-group level educational attainment was used as our main area level SES indicator. Educational attainment is a strong predictor of cardiovascular disease and is a commonly used SES measure.[27] Previous studies have additionally found area level education to be related to $PM_{2.5}$ levels.[28] In the current study, we defined area level educational attainment as the percentage of males and females in the block group without a high school education.

Rural-Urban Commuting Area Codes (RUCAs) at the census tract level were used to characterize each participant's urban/rural status. These codes use data from the standard Bureau of Census urbanized area and urban cluster definitions to describe each U.S. census tract's degree of urbanicity.[29] Urban census tracts were those defined as a metropolitan area core (primary flow within an urbanized area).

Statistical Analyses

We first report descriptive statistics comparing the $PM_{2.5}$ exposure assignment approaches. We then compared individual minimum and maximum differences of exposure assessment approaches across individuals to assess extent of variability between exposure models. Finally, we examined correlations between the annual averages of each of the $PM_{2.5}$ exposure assignment methods to assess the extent of agreement among the exposure assessment approaches.

Logistic regression analysis was used to estimate odds ratios (OR) and 95% confidence intervals (CI) associated with a CAD index >23 or recent MI for each 1-$\mu g/m^3$ increase in annual average $PM_{2.5}$. Models were adjusted for sex, race/ethnicity, smoking status, area level attained education, and urban/rural status. We assessed associations in single and multipollutant models. Multipollutant models were additionally adjusted for annual average ozone concentrations using monitored ozone data during the warm season (April to October).

An additional objective of the current paper was to assess whether urban/rural status modifies the association between long-term $PM_{2.5}$ exposure and CAD. Therefore, we included an interaction term between continuous levels of $PM_{2.5}$ for each of the exposure metrics and urban/rural status. We then compared these models with the main effects model without interaction terms. The Likelihood Ratio Test (LRT) was used to assess potential effect modification and a cutoff of $p<0.20$ was used to indicate presence of modification. Statistical analyses were performed using SAS version 9.3 (Cary, NC).

RESULTS

The characteristics of the CATHGEN study population are shown in Table 2. The total study population consisted of 5,679 individuals; however there were 610 who did not have outcome information available for the CAD index, resulting in a final sample size of 5,069 for the CAD outcome. In general, cardiac catheterization visit dates were spread out evenly from 2002-2009 (data not shown). There were 2,491 (49%) participants who had a CAD index score >23, indicating presence of significant CAD. Further, there were 704 (12%) who had an MI within a year of their catheterization visit. The majority of the participants were male, non-Hispanic white, and were either overweight or obese.

There were slightly more participants that lived in rural areas (N=3,243). Additionally, rural participants had a higher prevalence of coronary artery disease and MIs compared to urban participants. Further, urban participants tended to live in areas of higher attained education and with higher median home values. However, on average, study participant characteristics did not differ significantly by urban/rural status.

Table 3 shows the distribution of exposure estimates for each of the exposure assignment methods. In general, there were fairly similar distributions across the exposure assessment methods, which could be because to varying extent, the satellite and CMAQ values were calibrated to monitored values. Mean annual average $PM_{2.5}$ levels ranged from 12.32 to 12.79 $\mu g/m^3$, with the 1km model showing the smallest mean annual average $PM_{2.5}$ level. The monitored and EPA-CMAQ results showed the most variation with SDs of 1.22 and 1.27, respectively. In general, $PM_{2.5}$ levels decreased in time from 2002 to 2009, as seen in Supplemental Table 1. Additionally, $PM_{2.5}$ levels were consistently higher in urban areas across exposure assignment methods (Supplemental Table 2).

Correlations between the annual averages of each of the $PM_{2.5}$ exposure assignment methods are shown in Table 4. There were strong positive correlations between the $PM_{2.5}$ monitored and modeled data, with coefficients ranging from 0.60 to 0.88. The highest correlation was between the EPA and GT CMAQ models, with a coefficient of 0.88. The 1km model showed strong correlations with the monitored and 10km model, with coefficients of 0.75 and 0.74 respectively. The EPA-CMAQ model was slightly less well correlated with the satellite models, though it had a strong correlation with the monitor data (0.72). The lowest correlation was between the 10km model and the monitor data. When conducting pairwise comparisons of the variation between the exposure assessment averages, the GT-CMAQ and EPA-CMAQ models showed the least amount of variation in averages (Supplemental Table 3). Further, participants' annual average exposure levels were highly correlated in each of the pairwise comparisons, and this did not differ by CAD or MI outcome status (as seen in Supplemental Figures 1 and 2).

The adjusted odds ratios for CAD and recent MI in relation to the $PM_{2.5}$ exposure metrics are shown in Table 5. There were positive associations seen across all of the $PM_{2.5}$ metrics. Specifically, we found a 4% (95%CI: 0.99-1.10) increase in the odds of significant CAD for each 1-μg/m^3 increase in $PM_{2.5}$ when using monitored estimates, 7% (95%CI: 1.02-1.13) for the EPA-CMAQ estimates, 10% (95%CI: 1.04-1.17) when using the GT-CMAQ estimates, 13% (95%CI: 1.06-1.21) increase for the 10km $PM_{2.5}$ estimates, and finally 9% (95%CI: 1.03-1.15) increase for the 1km satellite-based estimates. In general, 10km results were strongest in magnitude, though overall results were all fairly similar across exposure metrics. Additionally, for the $PM_{2.5}$-MI analyses, the monitored and EPA-CMAQ results were slightly more precise and the CMAQ results were slightly strongest in magnitude (GT-CMAQ OR: 1.22, 95%CI: 1.11-1.33; EPA-CMAQ OR: 1.20, 95%CI: 1.11-1.29), though results were comparable across exposure assessment methods.

We investigated associations in multipollutant models to assess if annual average ozone levels confounded the $PM_{2.5}$-CAD associations. Results were fairly similar for multipollutant models adjusted for ozone (Table 5). Specifically, for the $PM_{2.5}$-CAD associations overall results increased in strength and precision when $PM_{2.5}$ concentrations were adjusted for ozone concentrations. $PM_{2.5}$-MI results were less influenced by adjustment for ozone concentrations

We additionally assessed whether urban/rural status modified $PM_{2.5}$-CAD associations. Figure 2 shows the results for the modification by urban/rural status. We found significant modification by urban/rural status for the $PM_{2.5}$-CAD associations for the monitored (p=0.02) and EPA-CMAQ (p=0.05) models. Specifically, for the monitored data there was an OR of 1.11 (95% CI: 1.03, 1.20) for those living in urban areas and an OR of 0.99 for those living in rural areas (95% CI: 0.92, 1.06). For the EPA-CMAQ models, there was an OR of 1.13 (95% CI: 1.06, 1.22) for those living in urban areas and an OR of 1.03 for those living in rural areas (95% CI: 0.97, 1.10). $PM_{2.5}$-CAD associations did not differ by urban/rural status for the GT-CMAQ or the satellite-based models.

DISCUSSION

Many epidemiologic studies have reported associations between $PM_{2.5}$ and adverse cardiovascular outcomes. However, exposure assessment methods vary by study, making the results difficult to compare across studies. In this paper we looked at the association between adverse cardiovascular outcomes and $PM_{2.5}$ concentrations obtained using five different approaches: direct measurements taken from air quality monitors, derived measurements taken from two different models that use emissions inventories as the primary basis for calculating $PM_{2.5}$ concentrations, and two different models that primarily use $PM_{2.5}$ measurements obtained from satellites at either 10 km or 1 km resolution. Both the emissions-based and satellite models incorporate other factors such as information from ground based monitors, meteorological information, land use regression terms, and information from chemical transport models.

We found positive associations between long-term $PM_{2.5}$ exposure and severity of coronary artery disease as measured by the CAD index. These findings were consistent across all five of the exposure assignment approaches. This was not surprising since the annual average $PM_{2.5}$ values shown in Table 3 were very similar, and there were strong positive correlations of the annual averages between the various exposure assignment methods. These findings increase confidence that the association between $PM_{2.5}$ and coronary artery disease is robust and not due measurement error or some anomaly in one of the exposure assignment methods.

The findings between long-term $PM_{2.5}$ exposure and measures of CVD are consistent with a previous study, which reported associations between long-term $PM_{2.5}$ exposure and carotid intima-media thickness (CIMT), a subclinical measure of CVD.[30] Further, findings from two recent studies reported associations between long-term $PM_{2.5}$ and traffic-related air pollution and progression of coronary calcification, a marker of advanced atherosclerosis.[31, 32] We additionally found positive results between long-term $PM_{2.5}$ exposure obtained from all five exposure assignment methods and having a recent MI, which is consistent with findings from a recent study that found associations between long-term $PM_{2.5}$ and MIs when using satellite-based models.[11]

There have been a limited number of previous studies that have compared findings across exposure assessment methods. The majority of these studies have associated $PM_{2.5}$ concentrations with pregnancy and adverse outcomes during childhood, with two studies finding consistent results across exposure metrics,[33, 34] while one did not.[35] Sellier et al.[36] compared results for PM_{10} and NO2 exposure during pregnancy and infant birth weight when using air quality, dispersion, and LUR models. Their findings showed consistent results across exposure metrics for PM_{10} exposure, but inconsistent results across the included exposure metrics for NO2 exposure. Another recent study compared findings from several $PM_{2.5}$ models and found stronger results for cardiovascular mortality for the satellite-based models, particularly when land use terms and monitored data were incorporated into the model.[16]

Overall, $PM_{2.5}$-CAD associations were similar between monitored and modeled estimates of exposure. When using data from central site air quality monitors, we make the assumption that measurements at single site are representative of air quality over a larger area. In theory, one might have expected that increased resolution (10km vs 1 km for satellite or census tract vs 12 km for CMAQ) would result in less measurement error and more robust associations with health end points. However, this was not the case in our data. More advanced modeling techniques may also bring additional uncertainty into the resulting estimates and interpretation of results.[37] Further, increased resolution may play a role in reducing measurement error for spatially heterogeneous pollutants such as carbon monoxide and nitrogen oxides (NOx), but potentially less so for more homogenous pollutants with less spatial variation such as $PM_{2.5}$ and ozone.[37] Therefore, improvements in exposure assessment may be more meaningful for more spatially heterogeneous pollutants.[36] Furthermore, associations between short-term $PM_{2.5}$ exposure and health end points may benefit from increased resolution. Previous studies have found that air quality monitors adequately capture individual long-term $PM_{2.5}$ averages, while other studies have found monitors to less adequately capture short-term averages.[37-39]

Both the CMAQ and satellite-based models were calibrated to monitored data, which may explain some of the similarity in the results across exposure assessment methods. First, the CMAQ 12km gridded output was fused to monitored data using a space-time downscaler model, with the resulting output at the census tract level (for the EPA models) and 12km grids (for the Georgia Tech models). Further, both of the satellite-based models were additionally calibrated to monitored data. The 1km hybrid estimates additionally incorporated data from a chemical transport model (GEOS-Chem), as well as meteorological data and land use terms. Recent studies have shown the importance of calibrating remote sensing data to monitored data. Specifically, findings from Jerrett et al.[16] showed that the relative risks estimated from exposure models using ground-base information were generally larger than those with remote sensing data alone.[16] This study concluded that the remote sensing models that were calibrated to the monitored data showed an overall better fit compared to the models with only remote sensing data.

We assessed modification of the $PM_{2.5}$-CAD association by urban/rural status using rural-urban commuting area codes at the census tract level to characterize each participant's urban/rural status. Cathgen participants reside in both urban and rural locations across North

Carolina, thus providing an ideal population with adequate spatial variability. When using the monitored and EPA-CMAQ exposure assignment methods, we found stronger associations for those participants living in urban census tracts compared to rural residents. There are several plausible explanations for these findings. First, air quality monitors are primarily located in heavily populated urban areas, thus there would likely be increased exposure misclassification for those participants living in rural areas further away from monitors.[40] Further, for the EPA CMAQ models the home addresses were tethered to census tract centroids, and census tracts are much larger in rural than in urban areas, thus potentially increasing exposure misclassification for rural participants. Therefore, it is possible that our monitored and EPA-CMAQ model findings were due to more accurate exposure measurement for the urban participants, rather than true urban/rural exposure-response differences.[41] There were no differences among rural and urban participants for the satellite-based models or GT-CMAQ models. This finding may indicate that these models adequately capture $PM_{2.5}$ exposures for urban as well as rural participants. These findings additionally show the utility of using satellite-based models, and CMAQ models at a finer spatial resolution, to assess health effects of air pollution for both urban as well as rural participants.

This study has several limitations. Cardiac catheterization patients represent a selective population and therefore results may not be generalizable to the general population. Because of their diagnosis, many of them are taking multiple medicines (e.g. statins, beta blockers, anti-hypertensives), which could modify $PM_{2.5}$ associated health outcomes. Unfortunately, we did not have a complete record of medication usage and so were not able to assess effect modification by medication. Elderly, minority, and those of low SES are less likely to undergo invasive cardiac procedures; thus SES may limit participation into cardiac catheterization studies.[42, 43] However, the racial distribution of the Cathgen cohort reflects the overall racial distribution in North Carolina. Individuals may be less likely to go to hospitals for MIs if they reside in rural areas.[44] We controlled for area level attained education and urban/rural status, however we were unable to account for individual level SES indicators. $PM_{2.5}$ in North Carolina is dominated by emissions derived from mobile sources. Some of these models may perform differently in regions where multiple sources contribute to $PM_{2.5}$. We compared exposures, effect estimates, and precision of results from each exposure assignment method. We made no direct assessment of exposure misclassification, but this is of interest for future work. Finally, we only associated annual average $PM_{2.5}$ values (as a measure of long-term exposure) with adverse cardiovascular outcomes. It is possible that the models might perform differently using shorter averaging times.

The current study has several strengths. It is the first study to associate adverse CV outcomes in a susceptible population with $PM_{2.5}$ concentrations obtained from five different exposure assignment methods at different spatial resolutions. We used the coronary artery disease index as our main measure of coronary artery disease. The CAD index is a clinically confirmed severity index that assesses extent of atherosclerosis. Cathgen additionally has an adequate sample size and spatial variability throughout the state to conduct our main and modification analyses by urban/rural status. Additionally, our study took advantage of both monitored and modeled data, while making use of both satellite and CMAQ-based models at different spatial resolutions.

In summary, we found associations between long-term $PM_{2.5}$ exposure and both coronary artery disease and having an MI. Overall our results were fairly similar across exposure assessment methods, for both the CAD and MI outcome. We additionally found modification by rural/urban status for the monitored and EPA-CMAQ exposure assessment methods. Future analyses should consider the comparison of exposure metrics for short-term analyses and multi-pollutant models, as results may vary by study design, pollutant of interest, geographical location, and length of exposure.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Table 1. Description of the included exposure assessment methods

Exposure metric	Description	Main data inputs	Additional data inputs	Spatial resolution
1. Monitor	Monitored $PM_{2.5}$ data from the EPA's air quality system data mart	Monitor data		Nearest monitor

2. EPA CMAQ	Bayesian space-time downscaler model was used to fuse monitored data with 12km CMAQ data	CMAQ and monitor data		Census tract
3. GT CMAQ	CMAQ-observation data fusion (DF) was used to combine monitored data with chemical transport model quality fields	CMAQ and monitor data		12km
4. Satellite 10km	Satellite AOD data calibrated with monitored data	Remote sensing and monitor data		10km
5. Satellite 1km	Hybrid approach that combines satellite AOD data calibrated with monitored data and GEOS-chem predictions	GEOS-Chem, remote sensing and monitor data	Meteorological variables and land-use terms	1km

Abbreviations: AOD, aerosol optical depth; CMAQ, Community Multi-scale Air Quality.

Table 2. Characteristics of the CATHGEN study population, N (%).

	Total Cohort	**Urban**[a]	**Rural**
Total	5679	2436	3243
CVD outcomes			
CAD >23[b]	2491 (49)	950 (45)	1541 (52)
Recent MI	704 (12)	239 (10)	465 (14)
Age at time of enrollment in years (mean ± SD)	60.8 ± 12.1	61.1 ± 12.2	60.6 (12.0)
Gender			

Male	3471 (61)	1487 (61)	1984 (61)
Female	2208 (39)	949 (39)	1259 (39)
Body mass index (kg/m^2)			
<18.5 (Underweight)	80 (1)	30 (1)	50 (2)
18.5-24.9 (Normal weight)	1187 (21)	507 (21)	680 (21)
25.0-29.9 (Overweight)	1987 (35)	881 (36)	1106 (34)
≥30.0 (Obese)	2399 (42)	1006 (42)	1393 (43)
Missing	26	12	14
Race[c]			
Non-Hispanic white	4146 (73)	1722 (71)	2424 (75)
African American	1204 (21)	637 (26)	567 (17)
Other	329 (6)	77 (3)	252 (8)
History of smoking			
Yes	2664 (47)	1025 (42)	1639 (51)
No	3015 (53)	1411 (58)	1604 (49)
History of diabetes			
Yes	1660 (29)	696 (29)	964 (30)
No	4019 (71)	1740 (71)	2279 (70)
History of hypertension			
Yes	3882 (68)	1647 (68)	2235 (69)
No	1797 (32)	789 (32)	1008 (31)
Neighborhood educational attainment[d]			
Low	2290 (40)	542 (22)	1748 (54)
High	3389 (60)	1894 (78)	1495 (46)
Neighborhood median home value ($)			
<82,700	1400 (25)	228 (9)	1172 (36)
82,700-118,000	1403 (25)	477 (20)	926 (29)
118,000-166,500	1436 (25)	656 (27)	780 (24)
≥166,500	1414 (25)	1052 (44)	362 (11)
Missing	26	23	3

Abbreviations: CAD, coronary artery disease; CVD, cardiovascular disease; MI, myocardial infarction. [a]Urban status was defined as living in a metropolitan urban core census tract. [b]Binary measure of CAD (>23 CAD index). The total sample size for the CAD outcome is 5,069. [c]Other race/ethnicity includes Native American, Hispanic, Asian, and unknown. [d]Low educational attainment includes those who live in block groups where ≥25% of males and females have less than a high school education.

Table 3. Annual average $PM_{2.5}$ (ug/m^3) levels for CATHGEN participants.

	Mean (SD)	Min	25th percentile	Median	75th percentile	Max	IQR
$PM_{2.5}$ Monitor	12.76 (1.22)	6.56	12.34	12.97	13.6	16.04	1.26
$PM_{2.5}$ EPA CMAQ	12.79 (1.27)	6.79	12.49	13.05	13.57	19.56	1.08
$PM_{2.5}$ GT CMAQ	12.55 (1.03)	8.29	12.25	12.78	13.17	17.32	0.91
$PM_{2.5}$ Satellite 10km	12.38 (0.90)	8.57	12.15	12.5	12.94	14.35	0.79

$PM_{2.5}$ Satellite 1km	12.32 (1.10)	6.92	11.8	12.5	13.08	16.5	1.28

Table 4. Pearson correlation matrix comparing annual average $PM_{2.5}$ levels for CATHGEN participants.

	Monitor	EPA CMAQ	GT CMAQ	Satellite 10km	Satellite 1km
Monitor	1				
EPA CMAQ	0.72	1			
GT CMAQ	0.73	0.88	1		

Satellite 10km	0.60	0.65	0.78	1	
Satellite 1km	0.75	0.68	0.72	0.74	1

Table 5. Odds ratios and 95% confidence intervals for the associations between 1-ug/m^3 increase in $PM_{2.5}$ and select CVD outcomes. Results are shown for single and multipollutant models.

	CAD index >23		**MI in prior year**	
	Single pollutant models	**Multipollutant[a] models**	**Single pollutant models**	**Multipollutant models**
$PM_{2.5}$ Monitor	1.04 (0.99, 1.10)	1.07 (1.01, 1.13)	1.19 (1.10, 1.29)	1.19 (1.10, 1.28)

$PM_{2.5}$ EPA CMAQ	1.07 (1.02, 1.13)	1.08 (1.03, 1.14)	1.20 (1.11, 1.29)	1.21 (1.12, 1.30)
$PM_{2.5}$ GT CMAQ	1.10 (1.04, 1.17)	1.14 (1.07, 1.22)	1.22 (1.11, 1.33)	1.21 (1.10, 1.33)
$PM_{2.5}$ Satellite 10km	1.13 (1.06, 1.21)	1.14 (1.06, 1.22)	1.17 (1.06, 1.29)	1.17 (1.06, 1.29)
$PM_{2.5}$ Satellite 1km	1.09 (1.03, 1.15)	1.12 (1.06, 1.18)	1.16 (1.07, 1.26)	1.17 (1.07, 1.27)

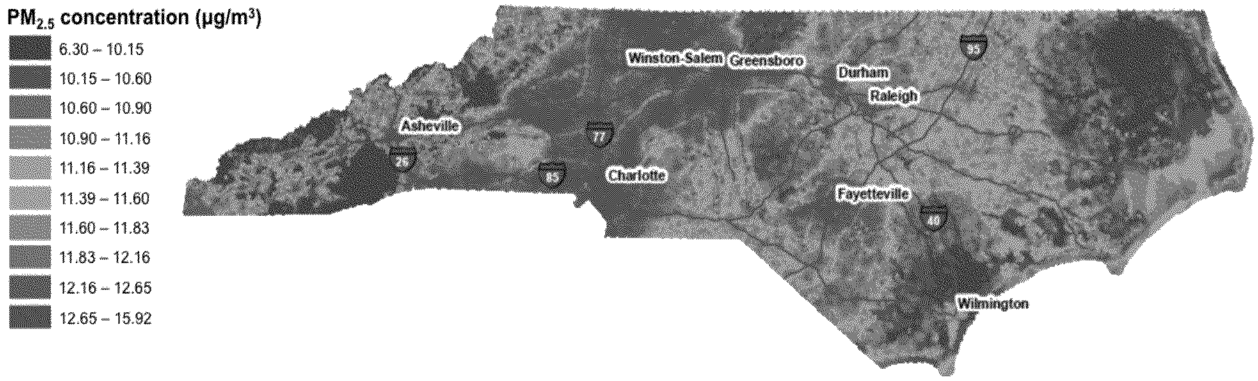
Abbreviations: CAD, coronary artery disease; MI, myocardial infarction. Models are adjusted for sex, smoking status, race, area level attained education, and urban/rural status. [a]Multipollutant models are additionally adjusted for monitored warm season ozone averages.

Figure Legends

Figure 1. Annual average 1x1 km² satellite-based $PM_{2.5}$ concentrations (μg/m³) for the state of North Carolina from 2002-2009.

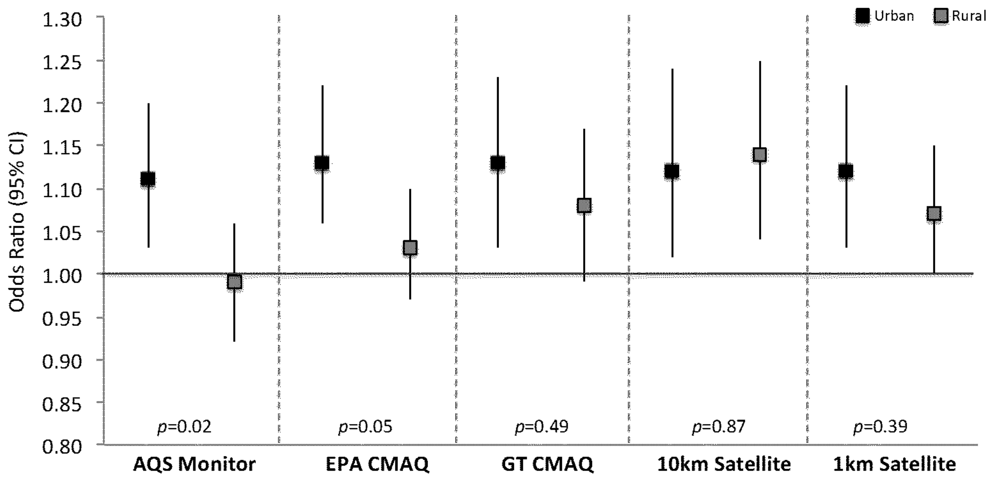
Figure 2. Modification of the $PM_{2.5}$-CAD association by urban/rural status. Results are shown for each of the five exposure assessment methods. Black squares represent urban participants and grey squares represent rural participants. Vertical lines represent 95% confidence intervals.

Figure 1.



PM2.5 concentration (μg/m3)
6.30 – 10.15
10.15 – 10.60
10.60 – 10.90
10.90 – 11.16
11.16 – 11.39
11.39 – 11.60
11.60 – 11.83
11.83 – 12.16
12.16 – 12.65
12.65 – 15.92
Winston-Salem
Greensboro
Durham
Raleigh
Asheville
Charlotte
Fayetteville
Wilmington
95
77
26
85
40

Figure 2.


Urban
Rural
Odds Ratio (95% CI)
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
p=0.02
p=0.05
p=0.49
p=0.87
p=0.39
AQS Monitor
EPA CMAQ
GT CMAQ
10km Satellite
1km Satellite

Supplemental Material

Long Term Air Pollution Exposure and Cardiovascular Disease: Comparison of Exposure Assessment Methods

Table of Contents

Table S1. Descriptive statistics for $PM_{2.5}$ exposure in NC from 2002-2009

Exposure Metric		Mean (SD)	25%	Median	75%	Max	IQR
Monitor	2002	13.1 (6.7)	8.4	11.7	16.7	62.7	8.3
	2003	12.8 (6.7)	7.9	11.7	16.6	50.0	8.7
	2004	13.3 (6.8)	8.2	12.3	17.1	43.9	8.9
	2005	13.6 (7.2)	8.2	12.3	17.7	69.5	9.5
	2006	13.1 (6.8)	8.1	11.8	17.0	84.1	8.9
	2007	12.9 (6.8)	7.6	11.5	16.9	61.0	9.3
	2008	11.7 (6.0)	7.5	10.7	14.9	107.6	7.4
	2009	9.4 (4.3)	6.3	8.8	11.9	38.1	5.6
EPA CMAQ	2002	12.6 (6.3)	8.1	11.4	15.6	76.4	7.5
	2003	13.1 (6.2)	8.7	12.0	13.1	56.3	4.5
	2004	12.6 (6.0)	8.1	11.6	15.9	67.5	7.8
	2005	13.6 (7.7)	8.5	12.2	17.3	62.1	8.8
	2006	13.0 (6.3)	8.3	11.8	16.5	63.0	8.2
	2007	12.6 (6.6)	7.6	11.1	16.2	53.4	8.6
	2008	11.5 (7.2)	6.5	9.5	14.7	56.1	8.1
	2009	9.5 (4.0)	6.6	8.9	11.8	28.3	5.2
GT CMAQ	2002	11. 9 (5.5)	7.9	11.0	14.7	56.6	6.8
	2003	11.2 (5.3)	7.4	10.4	14.2	54.5	6.8
	2004	11.8 (5.3)	7.8	11.1	15.0	208.7	7.3
	2005	12.1 (5.8)	7.7	11.2	15.4	115.9	7.7
	2006	11.7 (5.4)	7.7	10.9	14.9	60.8	7.3
	2007	11.5 (5.4)	7.3	10.5	14.8	50.6	7.6
	2008	10.2 (4.9)	6.6	9.5	13.0	95.6	6.4
	2009	8.8 (4.1)	5.9	8.2	10.9	49.0	5.0
Satellite 10km	2002	12.5 (6.1)	8.3	11.5	15.2	106.4	6.9
	2003	12.0 (5.5)	8.0	11.4	15.0	51.9	7.0
	2004	13.0 (5.6)	8.8	12.5	16.4	45.9	7.5
	2005	12.9 (6.0)	8.4	11.9	16.1	52.2	7.8
	2006	12.4 (5.8)	8.0	11.7	15.8	43.0	7.8
	2007	12.4 (6.0)	7.6	11.3	15.6	44.8	8.1
	2008	11.1 (5.2)	7.3	10.4	13.9	50.9	6.6
	2009	9.0 (3.7)	6.2	8.6	11.4	27.3	5.2
Satellite 1km	2002	11.9 (6.3)	7.7	10.5	14.6	65.6	6.9
	2003	11.4 (5.7)	7.4	10.4	14.4	58.4	7.1
	2004	12.1 (5.8)	7.6	11.3	15.5	53.0	7.9
	2005	13.0 (6.9)	7.9	11.6	16.6	66.2	8.7
	2006	12.0 (6.1)	7.6	10.8	15.4	67.7	7.9
	2007	11.9 (6.3)	6.9	10.6	15.9	55.3	8.9
	2008	10.5 (5.6)	6.4	9.4	13.5	94.2	7.1
	2009	8.1 (3.7)	5.3	7.5	10.3	41.7	5.0

Table S2. Annual average $PM_{2.5}$ (ug/m^3) levels for CATHGEN participants, stratified by urban/rural status.

	Urban		**Rural**	
	Mean (SD)	IQR	Mean (SD)	IQR
$PM_{2.5}$ Monitor	12.93 (1.26)	1.27	12.64 (1.16)	1.18
$PM_{2.5}$ EPA CMAQ	13.07 (1.30)	0.97	12.58 (1.21)	0.92
$PM_{2.5}$ GT CMAQ	12.78 (1.07)	0.94	12.38 (0.96)	0.86
$PM_{2.5}$ Satellite 10km	12.50 (0.97)	0.85	12.29 (0.83)	0.64
$PM_{2.5}$ Satellite 1km	12.61 (1.10)	1.22	12.10 (1.05)	1.12

Table S3. Individual mean, interquartile range, and maximum differences between annual average levels for each exposure model.

	Mean difference (SD)	IQR difference	Max difference
$PM_{2.5}$			
Monitor – EPA CMAQ	0.70 (0.61)	0.68	5.89
Monitor – GT CMAQ	0.68 (0.54)	0.65	4.45
Monitor – Satellite 10km	0.82 (0.68)	0.77	5.14
Monitor – Satellite 1km	0.72 (0.60)	0.75	5.63
EPA CMAQ – GT CMAQ	0.45 (0.47)	0.42	5.27
EPA CMAQ – Satellite 10km	0.79 (0.69)	0.71	6.78
EPA CMAQ – Satellite 1km	0.81 (0.70)	0.85	6.13
GT CMAQ – Satellite 10km	0.48 (0.48)	0.43	3.98
GT CMAQ – Satellite 1km	0.62 (0.55)	0.69	4.73
Satellite 10km – Satellite 1km	0.59 (0.46)	0.60	3.30

Table S4. Associations between 1-unit increases in $PM_{2.5}$ and CAD, stratified by urban/ rural status.

Air pollution Metric		Odds ratio	95% CI	Interaction p-value
Monitor				
	Urban	1.11	1.03, 1.20	
	Rural	0.99	0.92, 1.06	***p*=0.02**
EPA CMAQ				
	Urban	1.13	1.06, 1.22	
	Rural	1.03	0.97, 1.10	***p* =0.05**
GT CMAQ				
	Urban	1.13	1.03, 1.23	
	Rural	1.08	0.99, 1.17	*p* =0.49
Satellite 10km				
	Urban	1.12	1.02, 1.24	
	Rural	1.14	1.04, 1.25	*p* =0.87
Satellite 1km				
	Urban	1.12	1.03, 1.22	
	Rural	1.07	1.00, 1.15	*p* =0.39

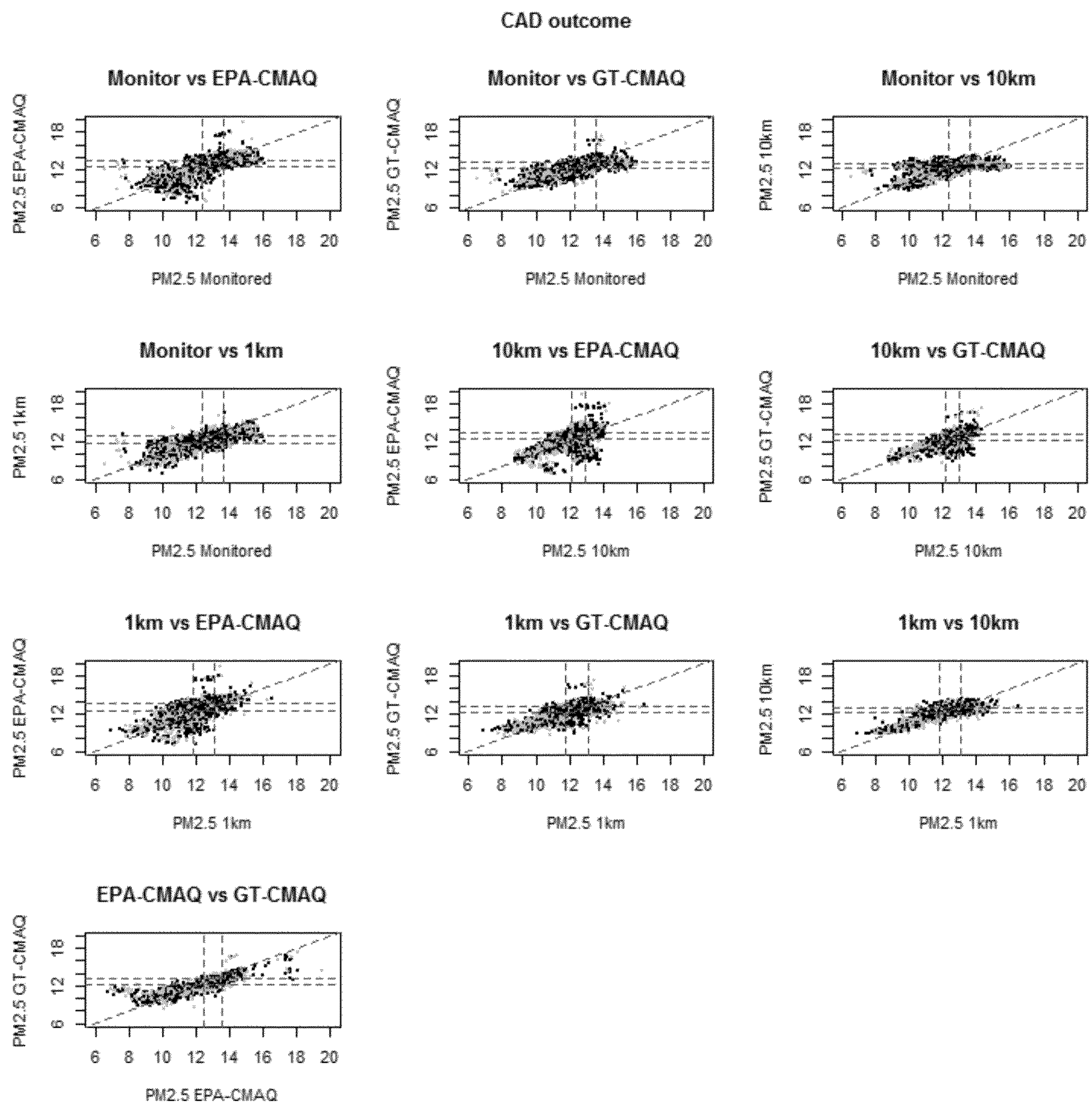


Figure S1. Plots of annual average $PM_{2.5}$ levels, by CAD outcome status. Black dots represent those participants with a CAD index score >23, while grey dots represent those with a CAD index score <23. The X and Y-axes represent the $PM_{2.5}$ averages for the corresponding exposure metric. The blue dashed line represents the Y=X line and the green dashed lines indicate the 25th and 75th percentile for each exposure metric. Inconsistent observations between the two exposure assignment methods are located in the upper left and lower right quadrants.

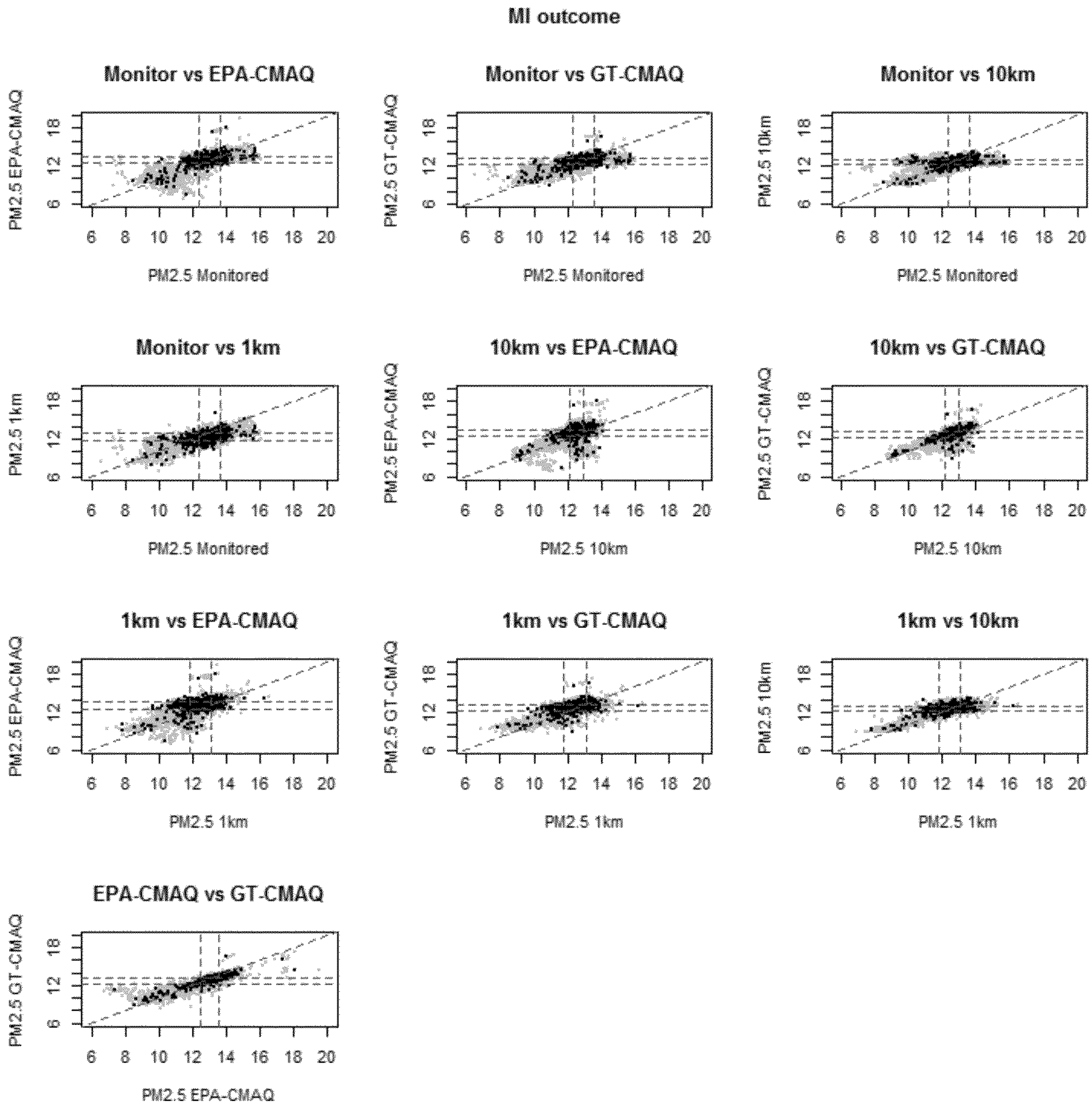


Figure S2. Plots of annual average $PM_{2.5}$ levels, by MI outcome status. Black dots represent those participants with a recent MI. The X and Y-axes represent the $PM_{2.5}$ averages for the corresponding exposure metric. The blue dashed line represents the Y=X line and the green dashed lines indicate the 25th and 75th percentile for each exposure metric. Inconsistent observations between the two exposure assignment methods are located in the upper left and lower right quadrants.

Table 1. Characteristics of the CATHGEN study population, N (%)

	N (%)
CVD outcomes	
CAD >23[a]	2,491 (49)
MI within a year	704 (12)
Age at time of enrollment in years (mean ± SD)	60.8 ± 12.1
Gender	
Male	3,471 (61)
Female	2,208 (39)
Body mass index (kg/m^2)	
<18.5 (Underweight)	80 (1)
18.5-24.9 (Normal weight)	1,187 (21)
25.0-29.9 (Overweight)	1,987 (35)
≥30.0 (Obese)	2,399 (42)
Missing	26
Race[b]	
Non-Hispanic white	4,146 (73)
African American	1,204 (21)
Other	329 (6)
History of smoking	
Yes	2,664 (47)
No	3,015 (53)
History of diabetes	
Yes	1,660 (29)
No	4,019 (71)
History of hypertension	
Yes	3,882 (68)
No	1,797 (32)
Neighborhood urban/ rural status[c]	
Urban	3,110 (55)
Rural	2,569 (45)
Neighborhood educational attainment[d]	
Low	2,290 (40)
High	3,389 (60)
Neighborhood median home value ($)	
<82,700	1,400 (25)
82,700-118,000	1,403 (25)
118,000-166,500	1,436 (25)
≥166,500	1,414 (25)
Missing	26

[a]Binary measure of CAD index (>23 CAD index). The total sample size for the CAD outcome is 5,069. [b]Other race/ethnicity includes Native American, Hispanic, Asian, and unknown. [c]Urban status was defined as living in a block group that was ≥50% urban. [d]Low educational attainment includes those who live in block groups where ≥25% of males and females have less than a high school education.

Table 2. Annual average $PM_{2.5}$ (ug/m^3) and ozone (ppb) levels for Cathgen participants

	Mean (SD)	Min	25th pctl	Median	75th pctl	Max	IQR
$PM_{2.5}$							
AQS $PM_{2.5}$	12.76 (1.22)	6.56	12.34	12.97	13.6	16.04	1.26
CMAQ-DS $PM_{2.5}$	12.79 (1.27)	8.68	12.5	13.05	13.57	19.56	1.07
10x10 km $PM_{2.5}$	12.38 (0.90)	8.57	12.15	12.5	12.94	14.35	0.79
Hybrid 1x1 km $PM_{2.5}$	12.32 (1.10)	6.92	11.8	12.5	13.08	16.5	1.28
Ozone							
AQS Ozone	49.6 (3.63)	37.5	46.9	49.4	52.5	62.7	5.6
CMAQ-DS Ozone[a]	48.3 (4.76)	36.6	44.5	49	51.6	59.7	7.1
Hybrid 1x1 km Ozone	47.8 (3.57)	37	45.2	47.6	50.4	59.5	5.2

[a]Downscaler, CMAQ-fused estimates

Table 3. Pearson correlation matrix comparing annual averages for Cathgen participants

	$PM_{2.5}$ AQS	$PM_{2.5}$ CMAQ-DS	$PM_{2.5}$ 10km	$PM_{2.5}$ 1km hybrid	AQS O3	O3 DS	O3 1km
$PM_{2.5}$ AQS	1						
$PM_{2.5}$ CMAQ-DS	0.72	1					
$PM_{2.5}$ 10km	0.6	0.65	1				
$PM_{2.5}$ 1km hybrid	0.75	0.68	0.74	1			
O3 AQS	0.4	0.37	0.27	0.39	1		
O3 DS	-0.003	0.14	0.14	0.06	0.35	1	
O3 1km	0.28	0.23	0.1	0.24	0.69	0.21	1

Table 4. Associations between 1- ug/m^3 increase in $PM_{2.5}$ and 5-ppb increase in ozone and select CVD outcomes

	CAD index >23 OR (95% CI)	MI in prior year OR (95% CI)		
$PM_{2.5}$				
AQS $PM_{2.5}$	1.04 (0.99, 1.10)	1.19 (1.10, 1.28)	1.11	1.16364
CMAQ-DS $PM_{2.5}$	1.07 (1.02, 1.13)	1.20 (1.11, 1.29)	1.11	1.16216
10x10 km $PM_{2.5}$	1.13 (1.06, 1.21)	1.17 (1.06, 1.29)	1.14	1.21698
Hybrid 1km $PM_{2.5}$	1.09 (1.03, 1.15)	1.16 (1.07, 1.26)	1.12	1.17757
Ozone[a]				
AQS Ozone	0.93 (0.86, 1.01)	1.12 (1.00, 1.25)	1.17	1.25
CMAQ-DS Ozone	0.95 (0.89, 1.01)	0.98 (0.90, 1.07)	1.13	1.18889
Hybrid 1km Ozone	0.86 (0.79, 0.93)	1.02 (0.91, 1.14)	1.18	1.25275

*Models are adjusted for sex, smoking status, race, area level attained education, and urban/rural status

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2002

	Mean (SD)	Min	25th pctl	Median	75th pctl
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	12.5 (6.1)	1.9	8.3	11.5	15.2
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21	7.7	10.5	14.6
Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	42.7 (16.7)	3.4	29.2	40.6	54.1

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2003

	Mean (SD)	Min	25th pctl	Median	75th pctl
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	12.0 (5.5)	1.7	8	11.4	15
Hybrid 1x1 km $PM_{2.5}$					
Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	40.6	1.1	30.3	38.7	49.3

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2004

	Mean (SD)	Min	25th pctl	Median	75th pctl
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	13.0 (5.6)	2.3	8.8	12.5	16.4
Hybrid 1x1 km $PM_{2.5}$					
Ozone					

	Mean (SD)	Min	25th pctl	Median	75th pctl
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	39.2 (12.6)	4.3	29.1	38.4	47.6

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2005

	Mean (SD)	**Min**	**25th pctl**	**Median**	**75th pctl**
$PM_{2.5}$					
AQS PM2.5	13.6 (7.2)	0	8.2	12.3	17.7
CMAQ-DS PM2.5	13.6 (7.7)	0.17	8.5	12.2	17.3
10x10 km PM2.5	12.5 (6.1)	1.9	8.3	11.9	16.1
Hybrid 1x1 km PM2.5	13.0 (6.9)	0.49	7.9	11.6	16.6
Ozone					
AQS Ozone	49.9 (16.0)	2	40	51	61
CMAQ-DS Ozone	45.8 (15.0)	3.7	32.3	42.3	54.2
Hybrid 1x1 km Ozone	41.0 (13.0)	2.3	30.2	40.3	50.7

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2006

	Mean (SD)	**Min**	**25th pctl**	**Median**	**75th pctl**
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	12.4 (5.8)	2	8	11.7	15.8
Hybrid 1x1 km $PM_{2.5}$					
Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	42.0 (12.4)	2.7	31.9	41.1	51.1

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2007

	Mean (SD)	**Min**	**25th pctl**	**Median**	**75th pctl**
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	12.4 (6.0)	1.1	7.6	11.3	15.6
Hybrid 1x1 km $PM_{2.5}$					

Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	44.2 (12.9)	7.3	33.9	44.6	53.7

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2008

	Mean (SD)	**Min**	**25th pctl**	**Median**	**75th pctl**
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	11.1 (5.2)	1.1	7.3	10.4	13.9
Hybrid 1x1 km $PM_{2.5}$					
Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	42.1 (12.5)	2.8	32.1	41.3	51.5

Table . Average $PM_{2.5}$ (ug/m^3) and ozone (ppb) concentrations for the year 2009

	Mean (SD)	**Min**	**25th pctl**	**Median**	**75th pctl**
$PM_{2.5}$					
AQS $PM_{2.5}$					
CMAQ-DS PM2.5					
10x10 km $PM_{2.5}$	9.0 (3.7)	1.1	6.2	8.6	11.4
Hybrid 1x1 km $PM_{2.5}$					
Ozone					
AQS Ozone					
CMAQ-DS Ozone					
Hybrid 1x1 km Ozone	37.7 (10.2)	3	30.1	37.8	44.9

Max	IQR
106.4	6.9
65.6	6.9
134	20.5

Max	IQR
51.9	7
189.2	19.0

Max	IQR
45.9	7.5

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

AQS $PM_{2.5}$

CMAQ-DS PM2.5

10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

2002

		AQS $PM_{2.5}$		
		CMAQ-DS PM2.5		
153.1	18.5	10x10 km $PM_{2.5}$	12.5 (6.1)	1.9
		Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	0.21

Max	IQR
69.5	9.5
62.1	8.8
52.2	7.8
66.2	8.7
111	21
107.5	21.9
212.3	20.5

Max	IQR
43	7.8
98.2	19.2

Max	IQR
44.8	8.1

97.5	19.8

Max	IQR
50.9	6.6
106.4	19.4

Max	IQR
27.3	5.2
113.9	14.8

					AQS	
					2002	
					2003	
8.3	11.5	15.2	106.4	6.9	2004	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	2005	11.9 (6.3)
					2006	
					2007	
					2008	
8.3	11.5	15.2	106.4	6.9	2009	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	CMAQ-DS PM2.5	11.9 (6.3)
					2002	
					2003	
					2004	
8.3	11.5	15.2	106.4	6.9	2005	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	**2006**	11.9 (6.3)
					2007	
					2008	
					2009	
8.3	11.5	15.2	106.4	6.9	10x10 km $PM_{2.5}$	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	2002	11.9 (6.3)
					2003	
					2004	
					2005	
8.3	11.5	15.2	106.4	6.9	**2006**	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	2007	11.9 (6.3)
					2008	
					2009	
					CMAQ-DS PM2.5	
8.3	11.5	15.2	106.4	6.9	2002	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	2003	11.9 (6.3)
					2004	
					2005	
					2006	
8.3	11.5	15.2	106.4	6.9	2007	12.5 (6.1)
7.7	10.5	14.6	65.6	6.9	2008	11.9 (6.3)
					2009	

AQS $PM_{2.5}$						
CMAQ-DS PM2.5						
10x10 km $PM_{2.5}$	12.5 (6.1)	8.3	11.5	15.2	106.4	6.9
Hybrid 1x1 km $PM_{2.5}$	11.9 (6.3)	7.7	10.5	14.6	65.6	6.9

1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9
1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9

1.9	8.3	11.5	15.2	106.4	6.9
0.21	7.7	10.5	14.6	65.6	6.9

Supplementary Table

	Mean (SD)	Min	25th pctl	Median	75th pctl	Max	IQR
AQS							
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
CMAQ-DS							
2002	12.56368 (6.277643)	0.654	6.068	11.395	15.6	76.43	7.532
2003	13.12453 (6.1586)	0.682	8.661	12.005	13.125	56.254	4.464
2004	12.60572 (6.038377)	0.266	8.095	11.576	15.923	67.476	7.828
2005	13.6 (7.7)	0.17	8.5	12.2	17.3	62.1	8.8
2006	12.97328 (6.2960)	0.06	8.276	11.752	16.469	63.033	8.193
2007	10.537 (5.049212)	0.739	6.848	9.392	13.232	41.271	6.384
2008							
2009							
10km							
2002							
2003							
2004							
2005							
2006							
2007							
2008							
2009							
1km							
2002	11.93 (6.31)	0.2135	7.6638	10.466	14.605	65.575	
2003							
2004	12.055 (5.814)	0.51	7.619	11.272	15.506	53.02	
2005	13.013 (6.864)	0.489	7.867	11.585	16.586	66.228	
2006	12.0435 (6.09)	0.81	7.5786	10.806	15.44	67.73	
2007	11.897 (6.306)	0.64	6.934	10.648	15.868	55.3	
2008	10.50 (5.619)	0.00379		9.386	13.498	94.225	
2009	8.10995 (3.688962)	0.08738	5.3267	7.5479	10.345	41.747	
2000	13.691 (7.13)	0.268	8.51	12.382	17	93.589	
2001	12.37 (6.09)	0.54	7.93	11.35	15.58	78.097	
2010	9.8617 (4.723357)	0.3287	6.2315	9.1263	12.639	54.508	

AQS PM2.5	13.6 (7.2)	0	8.2	12.3	17.7	69.5	9.5
CMAQ-DS PM2.5	13.6 (7.7)	0.17	8.5	12.2	17.3	62.1	8.8
10x10 km PM2.5	12.5 (6.1)	1.9	8.3	11.9	16.1	52.2	7.8
Hybrid 1x1 km PM2.5	13.0 (6.9)	0.49	7.9	11.6	16.6	66.2	8.7

CMAQ 2005

Supplemental Table 1. Change in PM2.5 Exposure Ranking N (%)

	to CMAQ	Monitor to 10km	Monitor to 1km	CMAQ to 10km	CMAQ to 1km	10km to 1km
No change in ranking	2427 (43)	2348 (41)	2870 (51)	2553 (45)	2591 (46)	2381 (42)
1 quartile higher (more exp	1160 (20)	958 (17)	1251 (22)	1029 (18)	1165 (21)	1192 (21)
2 quartiles higher	460 (8)	551 (10)	210 (4)	388 (7)	399 (7)	431 (8)
3 quartiles higher	35 (1)	127 (2)	19 (0.3)	110 (2)	39 (1)	72 (1)
1 quartile lower (less exp)	1055 (19)	1090 (19)	960 (17)	1133 (20)	971 (17)	1017 (18)
2 quartiles lower	494 (9)	462 (8)	337 (6)	396 (7)	433 (8)	505 (9)
3 quartiles lower	48 (1)	143 (3)	32 (1)	70 (1)	81 (1)	81 (1)
% Agreement	42.7	41.4	50.5	45	45.6	41.9
Kappa	0.24	0.22	0.34	0.27	0.28	0.23

A. Pairwise comparisons - with annual averages standardized

	Mean	SD	Min difference	Max difference		
PM2.5						
AQS - CMAQ	0.56433	0.48958	0.00005	4.80205		standardize
AQS - 10km	0.65919	0.60400	0.00052	4.55049		
AQS - 1km	0.51903	0.47354	4.89E-06	5.07825	most different	
CMAQ - 10km	0.57718	0.59892	0.00010	4.98918		
CMAQ - 1km	0.59138	0.53484	7.35E-06	4.31635		
10km - 1km	0.56906	0.43485	0.00034	3.10230	most similar	
Ozone						
AQS - 1km	0.61947	0.49020	0.00034	2.55747	most similar	
AQS - CMAQ	0.89443	0.70252	0.00022	5.45607	most different	
1km - CMAQ	0.99542	0.77138	0.00001	5.13612		

B. Individual min and max differences averaged across participants

PM2.5	Mean	Min	Max
Average min difference	0.16512	0.00002	1.65218
Average max difference	1.34718	0.06296	6.78025
Average SD	0.6	0.02	3.06
Ozone			
Average min difference	1.30446	0.00051	7.72962
Average max difference	5.24980	0.02371	23.17887
Average SD	2.76	0.01	12.6

Standardized variables

PM2.5	Mean	Min	Max
Average min difference	0.12743	4.89E-06	1.46132
Average max difference	1.05783	0.03794	5.07825
Average SD	0.47	0.17	2.32
Ozone			
Average min difference	0.32464	0.00001	1.61267
Average max difference	1.25466	0.01138	5.45607
Average SD	0.66	0.006	3.06

d differences

Supplemental Table 2. Individual minimum and maxium differences between models

	difference (SD)	differenc e	differenc e
PM2.5			
AQS - CMAQ	0.56 (0.49)	0	4.80
AQS - 10km	0.66 (0.60)	0	4.55
AQS - 1km	0.52 (0.47)	0	5.08
CMAQ - 10km	0.58 (0.60)	0	4.99
CMAQ - 1km	0.59 (0.53)	0	4.32
10km - 1km	0.57 (0.43)	0	3.10
Ozone			
AQS - 1km	0.62 (0.49)	0	2.56
AQS - CMAQ	0.89 (0.70)	0	5.46
1km - CMAQ	1.00 (0.77)	0	5.14

Supplemental Table 3. Individual minimum and maximum differences between models averaged across participants

	Mean	Min	Max
PM2.5			
Average min differenc	0.17	0.00	1.65
Average max differen	1.35	0.06	6.78
Average SD	0.60	0.02	3.06
Ozone			
Average min differenc	1.30	0.00	7.73
Average max differen	5.25	0.02	23.18
Average SD	2.76	0.01	12.60
Standardized variables			
PM2.5	Mean	Min	Max
Average min differenc	0.13	0.00	1.46
Average max differen	1.06	0.04	5.08
Average SD	0.47	0.17	2.32
Ozone			
Average min differenc	0.32	0.00	1.61
Average max differen	1.25	0.01	5.46
Average SD	0.66	0.01	3.06

Table. Associations between 1- ug/m^3 increase in $PM_{2.5}$ and 5-ppb increase in ozone and select CVD outcomes

	CAD index >23 OR (95% CI)	MI in prior year OR (95% CI)
$PM_{2.5}$		
AQS $PM_{2.5}$	1.07 (1.02, 1.13)	1.20 (1.11, 1.29)
CMAQ-DS $PM_{2.5}$	1.10 (1.04, 1.15)	1.20 (1.12, 1.30)
10x10 km $PM_{2.5}$	1.14 (1.06, 1.22)	1.17 (1.06, 1.29)
Hybrid 1km $PM_{2.5}$	1.12 (1.06, 1.18)	1.17 (1.07, 1.27)
Ozone[a]		
AQS Ozone	0.87 (0.80, 0.95)	1.04 (0.92, 1.17)
CMAQ-DS Ozone	0.94 (0.89, 1.00)	0.97 (0.89, 1.06)
Hybrid 1km Ozon	0.83 (0.76, 0.90)	0.97 (0.86, 1.10)

*Models are adjusted for sex, smoking status, race, area level attained education, and urban/rural status

PM2.5 models are adjusted for 1km ozone
Ozone models are adjusted for 1km PM2.5

Supplemental Table 4. Associations between 1- ug/m3 increase in PM2.5 and 5-ppb increase in ozone and select CVD outcomes. Results are shown for all participants and those within 20km of an EPA monitor.

	CAD index >23		**MI in prior year**	
	Any distance	**Within 20km of an EPA monitor**	**Any distance**	**Within 20km of an EPA monitor**
$PM_{2.5}$				
AQS $PM_{2.5}$	1.04 (0.99, 1.10)	1.08 (1.01, 1.15)	1.19 (1.10, 1.29)	1.22 (1.10, 1.34)
CMAQ-DS $PM_{2.5}$	1.07 (1.02, 1.13)	1.13 (1.07, 1.21)	1.20 (1.11, 1.29)	1.26 (1.14, 1.39)
10x10 km $PM_{2.5}$	1.13 (1.06, 1.21)	1.10 (1.02, 1.20)	1.17 (1.06, 1.29)	1.22 (1.07, 1.39)
Hybrid 1km $PM_{2.5}$	1.09 (1.03, 1.15)	1.12 (1.05, 1.21)	1.16 (1.07, 1.26)	1.19 (1.07, 1.32)
Ozone				
AQS Ozone	0.93 (0.86, 1.01)	0.88 (0.80, 0.98)	1.12 (1.00, 1.25)	1.02 (0.88, 1.17)
CMAQ-DS Ozone	0.95 (0.89, 1.01)	0.89 (0.82, 0.95)	0.98 (0.90, 1.07)	0.97 (0.87, 1.33)
Hybrid 1km Ozone	0.86 (0.79, 0.93)	0.84 (0.76, 0.94)	1.02 (0.91, 1.14)	0.99 (0.85, 1.16)

*Models are adjusted for sex, smoking status, race, area level attained education, and urban/rural status

Supplemental Table 5. Associations between 1- ug/m3 increase in PM2.5 and 5-ppb increase in ozone and select CVD outcomes, single and multipollutant models.

	CAD index >23		**MI in prior year**	
	Single pollutant models	**Multipollutant models**	**Single pollutant models**	**Multipollutant models**
$PM_{2.5}$				
AQS $PM_{2.5}$	1.04 (0.99, 1.10)	1.07 (1.01, 1.13)	1.19 (1.10, 1.29)	1.19 (1.10, 1.28)
CMAQ-DS $PM_{2.5}$	1.07 (1.02, 1.13)	1.08 (1.03, 1.14)	1.20 (1.11, 1.29)	1.21 (1.12, 1.30)
10x10 km $PM_{2.5}$	1.13 (1.06, 1.21)	1.14 (1.06, 1.22)	1.17 (1.06, 1.29)	1.17 (1.06, 1.29)
Hybrid 1km $PM_{2.5}$	1.09 (1.03, 1.15)	1.12 (1.06, 1.18)	1.16 (1.07, 1.26)	1.17 (1.07, 1.27)
Ozone				
AQS Ozone	0.93 (0.86, 1.01)	0.90 (0.82, 0.98)	1.12 (1.00, 1.25)	1.01 (0.90, 1.14)
CMAQ-DS Ozone	0.95 (0.89, 1.01)	0.93 (0.88, 0.99)	0.98 (0.90, 1.07)	0.95 (0.87, 1.03)
Hybrid 1km Ozone	0.86 (0.79, 0.93)	0.83 (0.76, 0.90)	1.02 (0.91, 1.14)	0.97 (0.86, 1.10)

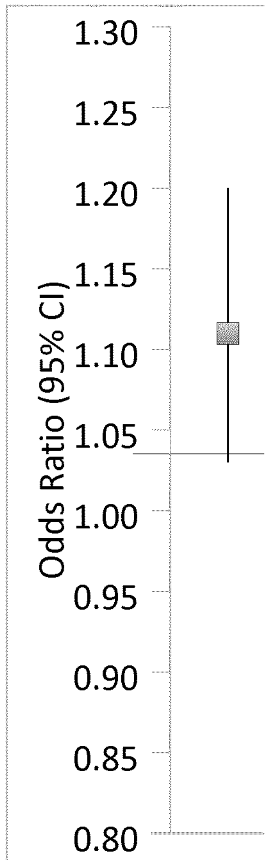
*Models are adjusted for sex, smoking status, race, area level attained education, and urban/rural status. PM2.5 multipollutant models are additionally adjusted for 1km ozone levels. Ozone multipollutant models are additionally adjusted for 1km PM2.5 levels.

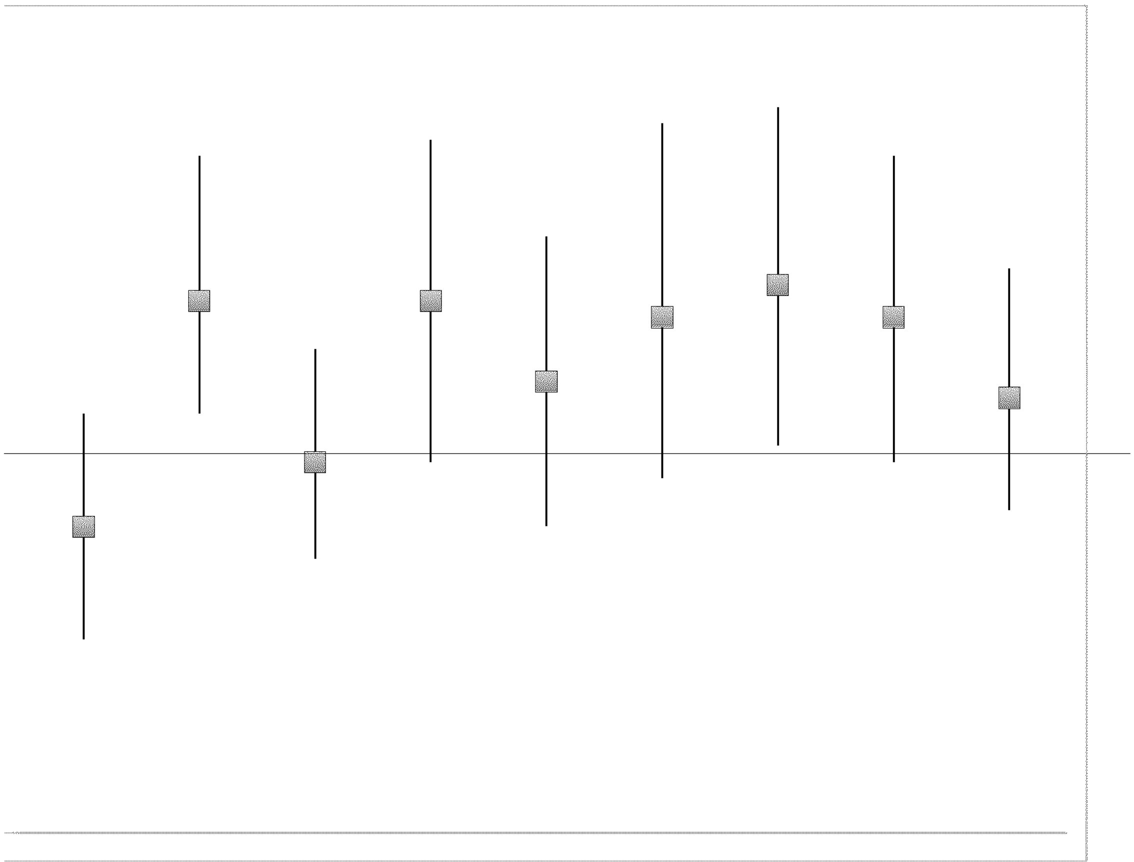
adjust for AQS ozone
adjust for CMAQ ozone
adjust for 1km ozone
adjust for 1km ozone

adjust for AQS PM
adjust for CMAQ PM
adjust for 1km ozone

	High	Low	Close		
Monitor	1.20	1.03	1.11		top=urban
	1.06	0.92	0.99	p=0.02	
CMAQ	1.22	1.06	1.13		
	1.10	0.97	1.03	p=0.05	
GT	1.23	1.03	1.13		
	1.17	0.99	1.08	p=0.49	
10km	1.24	1.02	1.12		
	1.25	1.04	1.14	p=0.87	
Hybrid 1km	1.22	1.03	1.12		
	1.15	1.00	1.07	p=0.39	

1=urban
0=rural





	CAD index >23 OR (95% CI)			MI in prior year OR (95% CI)		
	Urban	**Rural**	**p-value**	**Urban**	**Rural**	**p-value**
PM2.5						
AQS $PM_{2.5}$	1.11 (1.03, 1.20)	0.99 (0.92, 1.06)	0.02	1.29 (1.14, 1.46)	1.13 (1.03, 1.24)	0.1
CMAQ-DS $PM_{2.5}$	1.13 (1.06, 1.22)	1.03 (0.97, 1.10)	0.05	1.24 (1.10, 1.39)	1.17 (1.07, 1.29)	0.5
10x10 km $PM_{2.5}$	1.12 (1.02, 1.24)	1.14 (1.04, 1.25)	0.87	1.21 (1.04, 1.41)	1.14 (1.00, 1.29)	0.54
Hybrid 1km $PM_{2.5}$	1.12 (1.03, 1.22)	1.07 (1.00, 1.15)	0.39	1.30 (1.13, 1.50)	1.10 (0.99, 1.21)	0.05
Ozone[a]						
AQS Ozone	0.94 (0.84, 1.06)	0.93 (0.83, 1.03)	0.83	1.04 (0.87, 1.23)	1.18 (1.02, 1.37)	0.26
CMAQ-DS Ozone	0.90 (0.82, 0.98)	0.99 (0.91, 1.07)	0.12	0.88 (0.76, 1.02)	1.04 (0.94, 1.16)	0.07
Hybrid 1km Ozone	0.89 (0.78, 1.01)	0.83 (0.75, 0.93)	0.46	1.01 (0.83, 1.23)	1.02 (0.89, 1.18)	0.9

	CAD index >23 OR (95% CI)			MI in prior year OR (95% CI)		
	low 2nd pollutant	**high 2nd pollutant**	**p-value**	**low 2nd pollutant**	**high 2nd pollutant**	**p-value**
PM2.5						
AQS $PM_{2.5}$	1.02 (0.89, 1.17)	1.04 (0.98, 1.09)	0.82	1.22 (1.00, 1.50)	1.19 (1.10, 1.29)	0.8
CMAQ-DS $PM_{2.5}$	0.99 (0.88, 1.11)	1.09 (1.03, 1.15)	0.14	1.23 (1.03, 1.46)	1.19 (1.10, 1.29)	0.77
10x10 km $PM_{2.5}$	1.04 (0.91, 1.18)	1.16 (1.07, 1.25)	0.16	1.31 (1.06, 1.61)	1.12 (1.00, 1.26)	0.19
Hybrid 1km $PM_{2.5}$	1.06 (0.94, 1.20)	1.09 (1.02, 1.16)	0.65	1.23 (1.01, 1.49)	1.15 (1.05, 1.26)	0.53
Ozone[a]						
AQS Ozone	0.95 (0.85, 1.07)	0.85 (0.75, 0.96)	0.16	1.16 (0.99, 1.37)	1.01 (0.86, 1.19)	0.24
CMAQ-DS Ozone	0.95 (0.87, 1.04)	0.95 (0.88, 1.03)	0.98	1.01 (0.89, 1.14)	0.96 (0.86, 1.08)	0.62
Hybrid 1km Ozone	0.89 (0.79, 1.00)	0.81 (0.72, 0.91)	0.25	0.94 (0.80, 1.11)	1.08 (0.92, 1.27)	0.23

Table C. PM2.5 and CAD - additionally adjusted for urban/rural status

	PM2.5 Quartiles				
	Q1	Q2	Q3	Q4	*AIC*
CAD index >23					
AQS $PM_{2.5}$	1.00	1.08 (0.91, 1.27	1.06 (0.90, 1.25)	1.14 (0.97, 1.35	6725.658
CMAQ-DS $PM_{2.5}$	1.00	1.08 (0.92, 1.27	1.36 (1.15, 1.60)	1.25 (1.05, 1.49	6712.44
10x10 km $PM_{2.5}$	1.00	1.07 (0.91, 1.26	1.15 (0.98, 1.36)	1.21 (1.02, 1.42	6722.54
Hybrid 1km $PM_{2.5}$	1.00	1.26 (1.07, 1.48	1.34 (1.14, 1.58)	1.35 (1.13, 1.60	6712.32
MI in prior year					
AQS $PM_{2.5}$	1.00	1.74 (1.36, 2.21	1.64 (1.28, 2.09)	1.68 (1.31, 2.15	4175.47
CMAQ-DS $PM_{2.5}$	1.00	1.72 (1.36, 2.18	1.85 (1.45, 2.35)	1.52 (1.18, 1.97	4171.37
10x10 km $PM_{2.5}$	1.00	1.51 (1.20, 1.88	1.19 (0.94, 1.50)	1.12 (0.88, 1.43	4188.06
Hybrid 1km $PM_{2.5}$	1.00	1.52 (1.20, 1.92	1.72 (1.36, 2.17)	1.28 (0.99, 1.65	4177.86

Table F. Ozone and CAD - additionally adjusted for urban/rural status

	Ozone Quartiles				
	Q1	Q2	Q3	Q4	*AIC*
CAD index >23					
AQS Ozone	1.00	1.14 (0.97, 1.34	1.05 (0.90, 1.24)	0.91 (0.77, 1.07	6720.05
CMAQ-DS Ozone	1.00	0.90 (0.76, 1.05	0.86 (0.73, 1.01)	0.82 (0.70, 0.96	6721.84
Hybrid 1km Ozone	1.00	1.00 (0.85, 1.17	0.89 (0.75, 1.05)	0.79 (0.66, 0.93	6717.33
MI in prior year					
AQS Ozone	1.00	1.55 (1.22, 1.96	1.45 (1.14, 1.83)	1.37 (1.08, 1.74	4187.1
CMAQ-DS Ozone	1.00	0.89 (0.71, 1.11	0.82 (0.65, 1.04)	0.97 (0.78, 1.21	4198.62
Hybrid 1km Ozone	1.00	1.19 (0.95, 1.48)	1.21 (0.96 (1.52)	1.01 (0.80, 1.29	4197.51

Table 2. Annual average $PM_{2.5}$ (ug/m^3) and ozone (ppb) levels for Cathgen participants, stratified by urban/rural status

	Urban		Rural	
	Mean (SD)	**IQR**	**Mean (SD)**	**IQR**
$PM_{2.5}$				
AQS $PM_{2.5}$	12.93 (1.26)	1.27	12.64 (1.16)	1.18
CMAQ-DS $PM_{2.5}$	13.07 (1.30)	0.97	12.58 (1.21)	0.92
10x10 km $PM_{2.5}$	12.50 (0.97)	0.85	12.29 (0.83)	0.64
Hybrid 1x1 km $PM_{2.5}$	12.61 (1.10)	1.22	12.1	1.12
Ozone				
AQS Ozone	49.6 (3.63)	37.5	62.7	5.6
CMAQ-DS Ozone[a]	48.3 (4.76)	36.6	59.7	7.1
Hybrid 1x1 km Ozone	47.8 (3.57)	37	59.5	5.2

Exposure Metric	Mean (SD)	25%	Median	75%	Max	IQR
Monitor 2002	13.1 (6.7)	8.4	11.7	16.7	62.7	8.3
2003	12.8 (6.7)	7.9	11.7	16.6	50.0	8.7
2004	13.3 (6.8)	8.2	12.3	17.1	43.9	8.9
2005	13.6 (7.2)	8.2	12.3	17.7	69.5	9.5
2006	13.1 (6.8)	8.1	11.8	17.0	84.1	8.9
2007	12.9 (6.8)	7.6	11.5	16.9	61.0	9.3
2008	11.7 (6.0)	7.5	10.7	14.9	107.6	7.4
2009	9.4 (4.3)	6.3	8.8	11.9	38.1	5.6
EPA CMAQ 2002	12.6 (6.3)	8.1	11.4	15.6	76.4	7.5
2003	13.1 (6.2)	8.7	12.0	13.1	56.3	4.5
2004	12.6 (6.0)	8.1	11.6	15.9	67.5	7.8
2005	13.6 (7.7)	8.5	12.2	17.3	62.1	8.8
2006	13.0 (6.3)	8.3	11.8	16.5	63.0	8.2
2007	12.6 (6.6)	7.6	11.1	16.2	53.4	8.6
2008	11.5 (7.2)	6.5	9.5	14.7	56.1	8.1
2009	9.5 (4.0)	6.6	8.9	11.8	28.3	5.2
GT CMAQ 2002	11. 9 (5.5)	7.9	11.0	14.7	56.6	6.8
2003	11.2 (5.3)	7.4	10.4	14.2	54.5	6.8
2004	11.8 (5.3)	7.8	11.1	15.0	208.7	7.3
2005	12.1 (5.8)	7.7	11.2	15.4	115.9	7.7
2006	11.7 (5.4)	7.7	10.9	14.9	60.8	7.3
2007	11.5 (5.4)	7.3	10.5	14.8	50.6	7.6
2008	10.2 (4.9)	6.6	9.5	13.0	95.6	6.4
2009	8.8 (4.1)	5.9	8.2	10.9	49.0	5.0
Satellite 10km 2002	12.5 (6.1)	8.3	11.5	15.2	106.4	6.9
2003	12.0 (5.5)	8.0	11.4	15.0	51.9	7.0
2004	13.0 (5.6)	8.8	12.5	16.4	45.9	7.5
2005	12.9 (6.0)	8.4	11.9	16.1	52.2	7.8
2006	12.4 (5.8)	8.0	11.7	15.8	43.0	7.8
2007	12.4 (6.0)	7.6	11.3	15.6	44.8	8.1
2008	11.1 (5.2)	7.3	10.4	13.9	50.9	6.6
2009	9.0 (3.7)	6.2	8.6	11.4	27.3	5.2
Satellite 1km 2002	11.9 (6.3)	7.7	10.5	14.6	65.6	6.9
2003	11.4 (5.7)	7.4	10.4	14.4	58.4	7.1
2004	12.1 (5.8)	7.6	11.3	15.5	53.0	7.9
2005	13.0 (6.9)	7.9	11.6	16.6	66.2	8.7
2006	12.0 (6.1)	7.6	10.8	15.4	67.7	7.9
2007	11.9 (6.3)	6.9	10.6	15.9	55.3	8.9
2008	10.5 (5.6)	6.4	9.4	13.5	94.2	7.1
2009	8.1 (3.7)	5.3	7.5	10.3	41.7	5.0

		2002	2003	2004	2005	2006	2007
AQS (SD)	Mean	13.1 (6.7)	12.8 (6.7)	13.3 (6.8)	13.6 (7.2)	13.1 (6.8)	12.9 (6.8)
	Min	0	0	0	0	0	0
	25%	8.4	7.9	8.2	8.2	8.1	7.6
	Median	11.7	11.7	12.3	12.3	11.8	11.5
	75%	16.7	16.6	17.1	17.7	17	16.9
	Max	62.7	50	43.9	69.5	84.1	61
	IQR	8.3	8.7	8.9	9.5	8.9	9.3
AQS (SD)	Mean						
	Min						
	25%						
	Median						
	75%						
	Max						
	IQR						
AQS (SD)	Mean						
	Min						
	25%						
	Median						
	75%						
	Max						
	IQR						
AQS (SD)	Mean						
	Min						
	25%						
	Median						
	75%						
	Max						
	IQR						
AQS (SD)	Mean						

Min	
25%	
Median	
75%	
Max	
IQR	

2008	2009
11.7 (6.0)	9.4 (4.3)
0	0
7.5	6.3
10.7	8.8
14.9	11.9
107.6	38.1
7.4	5.6

	PM$_{2.5}$ Monitor	PM$_{2.5}$ EPA CMAQ
PM$_{2.5}$ Monitor		
PM$_{2.5}$ EPA CMAQ		
PM$_{2.5}$ GT CMAQ		
PM$_{2.5}$ Satellite 10km		
PM$_{2.5}$ Satellite 1km		

$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$
GT	Satellite	Satellite
CMAQ	10km	1km

To: Hubbell, Bryan[Hubbell.Bryan@epa.gov]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Mon 11/7/2016 3:04:33 PM
Subject: Re: Invitation to serve on SAC for Harvard ACE Center

Thanks Bryan
Soon we will ask your availability
Looking forward to you visit

On another note I would like to invite you to teach one or two lectures at my air pollution class
If you teach two you will have to come to Boston on Tuesday night and leave on Friday
We will cover all expenses

The first week of April is open but if you can not give me some other options

Sent from my iPhone

On Nov 7, 2016, at 9:37 AM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

Alice-

I received the invitation. I accept the invitation, and am very excited to be working with your Center.

Best,

Bryan

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Friday, November 04, 2016 4:29 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Invitation to serve on SAC for Harvard ACE Center

Dear Dr. Hubbell:

Please find attached a formal letter of invitation to serve on the Harvard ACE Center SAC.

Please would you let me know you received this.

Thank you,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Fri 1/13/2017 9:56:16 PM
Subject: Re: Teaching Petros's class - Feb 8?

Hi Alice, I am actually in the midst of changing positions in EPA and it's a little hard for me to commit to any additional travel for the next couple of months. When Petros and I last spoke about this we had talked about April. That might still be possible if he is interested.

Thanks,
Bryan

Sent from my iPhone

On Jan 13, 2017, at 4:50 PM, Smythe, Alice <asmythe@hsph.harvard.edu> wrote:

> Hi Dr. Hubbell,
> Petros is putting together his teaching schedule for spring and he wondered if there is the possibility that you might be able to teach on February 8th? This is on a Wednesday.
> Would you mind letting me know?
> Thanks and have a nice weekend.
>
> Alice
>
> Sent from my Virgin Mobile Phone.

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Thur 12/8/2016 10:02:10 PM
Subject: RE: Advice on Risk Management

No worries, I really want to be there in person.

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, December 08, 2016 5:01 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Subject: Re: Advice on Risk Management

Also Alice told me about your wife's birthday

I really appreciate this

Sent from my iPhone

On Dec 8, 2016, at 4:30 PM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

> Kimber-
>
> I want to connect you with Dr. Souzana Achilleos, a researcher at Harvard working on an air pollution risk management program in Cyprus through the Cyprus Institute. She works with Petros Koutrakis (one of our ACE Center grantees) and is looking for some advice on international air pollution risk management and I think you might be able to help her or direct her to some resources.
>
> Thanks!
>
> Bryan
>
> Dr. Bryan J. Hubbell

Senior Advisor for Science and Policy Analysis

U.S. EPA/OAQPS

Health and Environmental Impacts Division

MD C504-02

RTP, NC 27711

(919)541-0621

On Mon, Nov 21, 2016 at 8:31 AM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

Souzana-

We have a number of tools that are available for international risk assessment/health impact assessment that might be useful. They can be found at:

https://www.epa.gov/benmap

and

http://www.ccacoalition.org/en/content/about-us

Specifically for risk management actions, you can contact my colleague Kimber Scavo (Scavo.kimber@epa.gov), who works on international air quality agreements, including the Long Range Transboundary Air Pollution (LRTAP) program.

http://www.unece.org/env/lrtap/30anniversary.html

If you have any specific questions, feel free to send them to me and I will try to help get you answers.

Best of luck with your proposal,

Bryan

Dr. Bryan J. Hubbell

Senior Advisor for Science and Policy Analysis

U.S. EPA/OAQPS

Health and Environmental Impacts Division

MD C504-02

RTP, NC 27711

(919)541-0621

From: Souzana Achilleos [mailto:soa080@mail.harvard.edu]
Sent: Friday, November 18, 2016 1:19 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Euripides Stephanou <e.stephanou@cyi.ac.cy>
Subject: Advice on Risk Management

Dear Dr. Hubbell,

I hope this email finds you well.

My name is Souzana Achilleos and I am currently a postdoc research fellow at Harvard School of Public Health , working with Prof. Petros Koutrakis.

I am currently preparing a proposal for Cyprus in collaboration with The Cyprus Institute. We are proposing a source identification analysis, and a Risk Assessment-Risk Management analysis for the country. I am not an expert in the Risk Management analysis and I don't know anyone who can help us on this.

Petros referred me to you. We would really appreciate if you, or someone you may know here or in Europe, can help us on this.

Thank you so much. Please let me know if you need more details.

Best,

Souzana Achilleos

Souzana Achilleos, Sc.D.

Postdoctoral Research Fellow

Exposure, Epidemiology and Risk Program

Harvard School of Public Health

Landmark Center West, Room 422

401 Park Drive, Boston

MA, 02115

Tel.: 617-384-8848

Fax.:617-384-8859

To: Scavo, Kimber[Scavo.Kimber@epa.gov]; Souzana Achilleos[soa080@mail.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Thur 12/8/2016 9:30:11 PM
Subject: RE: Advice on Risk Management

Kimber-

I want to connect you with Dr. Souzana Achilleos, a researcher at Harvard working on an air pollution risk management program in Cyprus through the Cyprus Institute. She works with Petros Koutrakis (one of our ACE Center grantees) and is looking for some advice on international air pollution risk management and I think you might be able to help her or direct her to some resources.

Thanks!

Bryan

Dr. Bryan J. Hubbell

Senior Advisor for Science and Policy Analysis

U.S. EPA/OAQPS

Health and Environmental Impacts Division

MD C504-02

RTP, NC 27711

(919)541-0621

On Mon, Nov 21, 2016 at 8:31 AM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

Souzana-

We have a number of tools that are available for international risk assessment/health impact assessment that might be useful. They can be found at:

https://www.epa.gov/benmap

and

http://www.ccacoalition.org/en/content/about-us

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Souzana Achilleos, Sc.D.

Postdoctoral Research Fellow

Exposure, Epidemiology and Risk Program

Harvard School of Public Health

Landmark Center West, Room 422

401 Park Drive, Boston

MA, 02115

Tel.: 617-384-8848

Fax.:617-384-8859

To: Scavo, Kimber[Scavo.Kimber@epa.gov]; Souzana Achilleos [soa080@mail.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Thur 12/8/2016 9:28:20 PM
Subject: FW: Advice on Risk Management

Kimber-

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Thanks!

Bryan

Dr. Bryan J. Hubbell

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Tel.: 617-384-8848

Fax.:617-384-8859

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Tue 11/22/2016 1:19:33 PM
Subject: RE: Invitation to serve on SAC for Harvard ACE Center

Hi Petros-

Wednesday or Friday would be fine – I just misread your email. Looking forward to talking with your class!

Happy Thanksgiving to you all as well!

Bryan

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, November 21, 2016 4:40 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Re: Invitation to serve on SAC for Harvard ACE Center

Thanks Bryan

The class is supposed to be on Wednesdays or Fridays but this could change. I will be happy with one class. This will be a great help. I would like something about air quality regulations.

I will confirm the date in about a month and Alice will help you with travel.

As you my guess we are thrilled with the elections.

Happy thanksgiving

Petros

Sent from my iPhone

On Nov 21, 2016, at 3:22 PM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

Hi Petros-

I'm free the first week of April, but could probably only do either Tuesday or Friday but not both. What topics would you like me to focus on? I can cover a number of different areas related to air pollution regulations, risk analyses, cost-benefit analysis, etc.

Thanks!

Bryan

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, November 07, 2016 10:05 AM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Re: Invitation to serve on SAC for Harvard ACE Center

Thanks Bryan

Soon we will ask your availability

Looking forward to you visit

On another note I would like to invite you to teach one or two lectures at my air pollution class

If you teach two you will have to come to Boston on Tuesday night and leave on Friday

We will cover all expenses

The first week of April is open but if you can not give me some other options

Sent from my iPhone

On Nov 7, 2016, at 9:37 AM, Hubbell, Bryan <Hubbell.Bryan@epa.gov> wrote:

Alice-

I received the invitation. I accept the invitation, and am very excited to be working with your Center.

Best,

Bryan

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Friday, November 04, 2016 4:29 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Invitation to serve on SAC for Harvard ACE Center

Dear Dr. Hubbell:

Please find attached a formal letter of invitation to serve on the Harvard ACE Center SAC.

Please would you let me know you received this.

Thank you,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Mon 11/21/2016 8:22:01 PM
Subject: RE: Invitation to serve on SAC for Harvard ACE Center

Hi Petros-

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Thanks!

Bryan

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Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
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Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Mon 11/7/2016 2:37:03 PM
Subject: RE: Invitation to serve on SAC for Harvard ACE Center

Alice-

I received the invitation. I accept the invitation, and am very excited to be working with your Center.

Best,

Bryan

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Friday, November 04, 2016 4:29 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
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Alice Smythe

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Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Dominici, Francesca[fdominic@hsph.harvard.edu]
From: Hubbell, Bryan
Sent: Tue 6/6/2017 3:29:31 PM
Subject: RE: call? a time sensitive question

https://19january2017snapshot.epa.gov/cleanpowerplan/clean-power-plan-proposed-rule-regulatory-impact-analysis_.html

From: Dominici, Francesca [mailto:fdominic@hsph.harvard.edu]
Sent: Monday, June 05, 2017 3:22 PM
To: Hubbell, Bryan <Hubbell.Bryan@epa.gov>
Subject: call? a time sensitive question

Hi Bryan,

do you have time for a quick call later today or tomorrow? I have three specific questions regarding this document

https://www.epa.gov/sites/production/files/2014-06/documents/20140602fs-important-numbers-clean-power-plan.pdf

The document says "*reducing exposure to particle pollution and ozone in 2030 will avoid projected 2,700 to 6,600 premature deaths*"

Q1: based on which estimate of the hazard ratios? and based on which reduction of PM2.5?

The document also says " *The Clean Power Plan will reduce pollutants that contribute to the soot and smog that make people sick*

by over 25 percent in 2030. 54,000 to 56,000 tons of PM 2.5".

Q2: What is the absolute change in PM2.5? I cannot figure out the ton to mug/m^3 conversion. Is this a reduction from 5.4 to 5.6 mug/m^3?

Q3: instead of an estimate for the years 2030, do we have estimates of PM2.5 reduction per year expected from the implementation of the clean power plant rule?

Fell free to give me a ring if it is easier to discuss by phone (410-258-5886)

Thanks!!

FRANCESCA DOMINICI, PHD |

co-Director of the Harvard Data Science Initiative
Professor of Biostatistics | Department of Biostatistics
Harvard T.H. Chan School of Public Health
677 Huntington Avenue, 4-th Floor, Room 441, Building 2 | Boston, MA 02115
o: 617-432-4908| c: 410-258-5886 | f:617-432-5619
fdominic@hsph.harvard.edu
http://www.hsph.harvard.edu/francesca-dominici/

For appointments and scheduling please contact

Kirsten O'Brien
Email: kobrien@hsph.harvard.edu

FRANCESCA DOMINICI, PHD |

co-Director of the Harvard Data Science Initiative
Professor of Biostatistics | Department of Biostatistics
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For appointments and scheduling please contact

Kirsten O’Brien
Email: kobrien@hsph.harvard.edu

To: fdominic@hsph.harvard.edu[fdominic@hsph.harvard.edu]; ZEFTA@ccf.org[ZEFTA@ccf.org]; kito1@health.nyc.gov[kito1@health.nyc.gov]; Jennifer.Peel@ColoState.EDU[Jennifer.Peel@ColoState.EDU]; azanobet@hsph.harvard.edu[azanobet@hsph.harvard.edu]; joelschwrtz69@gmail.com[joelschwrtz69@gmail.com]; joel@hsph.harvard.edu[joel@hsph.harvard.edu]
Cc: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Sayikanmi, Catherine
Sent: Thur 7/6/2017 5:53:06 PM
Subject: SAVE THE DATE - Exploring New Air Pollution Health Effects - Existing Data

Hello everyone,

I am emailing you all, on behalf of Vito Ilacqua, in regards to the upcoming "Exploring New Air Pollution Health Effects - Existing Data" webinar. Based on the responses from the Doodle survey, the meeting will be scheduled for **Tuesday, September 12, 2017**. Please save this date in your calendars and look out for more information regarding the time and location from Vito. Thank you!

Best wishes,
Catherine

--

Catherine Sayikanmi

Peer Review and Research Support Associate

ORAU Student Services Contractor

EPA | ORD | NCER | ASED

sayikanmi.catherine@epa.gov

Phone 202.564.8876

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]; Vallarino, Jose[jvallari@hsph.harvard.edu]; Lawrence, Joy[lawrence@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Fri 12/16/2016 8:44:17 PM
Subject: Re: Comments on Harvard QMP (ACE Center)

Vito it was great to see you unfortunately the circumstances were not the best
However you did a great job and the meeting was well organized and informative

Happy holidays

Sent from my iPhone

On Dec 16, 2016, at 3:39 PM, Ilacqua, Vito <Ilacqua.Vito@epa.gov> wrote:

Dear Petros,

Thank you again for your time and your presentation at the meeting last week. It's always a pleasure talking with you.

I have not followed up on the QMP until now, but I need to check if your center has a revision, so we can finalize this requirement. Since I'm at it, this is also a reminder that the first year of this center has officially passed, so the annual center report will be due at the end of February.

Thank you and have a great weekend

Vito

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, August 31, 2016 11:48 AM

To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>; Vallarino, Jose <jvallari@hsph.harvard.edu>; Lawrence, Joy <lawrence@hsph.harvard.edu>
Subject: Re: Comments on Harvard QMP (ACE Center)

Hi Vito thanks for your email we will take care and respond

Regards petros

Sent from my iPhone

On Aug 31, 2016, at 6:45 PM, Ilacqua, Vito <Ilacqua.Vito@epa.gov> wrote:

Dear Petros,

Please find below the comments of our QC officer on the Quality Management Plan for the new center. It seems relatively straightforward to fix. Let me know if any questions come up.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

(202) 564 4512 | ilacqua.vito@epa.gov
National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

From: Doucet, Lisa
Sent: Wednesday, August 31, 2016 11:19 AM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Shanahan, Patrick <Shanahan.Patrick@epa.gov>
Subject: Comments on Harvard QMP (ACE Center)

Hi Vito – We reviewed the Harvard draft QMP and have a couple of comments that to address before we can approve.

1. QAPPs versus Research Plans. The Air Pollution Core will have a QAPP (compliant with R-5) but none of the projects will, is that correct? Table 2 does not list QAPPs for any of the activities. The requirement to document planning, implementation and assessment of projects is not limited to data generation activities. ANSI E-4(1) and EPA describe environmental data much more broadly (to include modelling, data use, method development). They do not necessarily have to write QAPPs consistent with EPA QA R-5 (2) for each project, however they do need to describe how each project is planned, how they will document that they did what was planned (or how they will address deviations from the plan), and how they will assess results. Research plans along with SOPs and data management plans should be sufficient documentation in lieu of QAPPs, but it's not clear what information the research plans include. The QMP describes use of research plans as working documents that will evolve during the course of the project. The project QA documentation should describe how decisions are made to adjust research and who reviews/approves those changes. The QMP needs to more fully describe what information is included in the RPs and describe the process for review and approval (by the QAM). If there is a template for what should be included in a research plan, that could be included as an attachment to the QMP or they could include a specific reference to one.

2. Section 3.7, first sentence. Per the Federal Grant and Cooperative Agreement Act and EPA Order 5700.1, EPA employees cannot provide input into on-going or

future research directions. They can only participate as observers in the meetings. Sentence needs to be changed to indicate that EPA will only participate as observers (or not at all).

3. Section 3.10 mentions compliance with the EPA Information Quality Guidelines[3]. Just note that while a good practice, grantee information is not subject to the EPA IQG.

4. On the title/signature page, change Vito Ilacqua to Lisa Doucet.

[1] ANSI/ASQC E-4-1994, *Specifications and Guidance for Quality Systems for Environmental Data Collection and Environmental Technology Programs*, 1995.

[2] *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* - March 2001 (Reissued May 2006), EPA/240/B-01/003.

[3] *EPA's Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by the Environmental Protection Agency* – October 2002, EPA/260R-02-008.

Lisa Doucet

U.S. EPA | Office of Research and Development

National Center for Environmental Research

Policy, Planning & Review Division

Program Operations Lead

202-564-4271

<QMP-New Center-as-jIJV-as.docx>

To: petros@hsph.harvard.edu[petros@hsph.harvard.edu]
Cc: HQgrantsnotification[HQgrantsnotification@epa.gov]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Brooks, Jennifer
Sent: Thur 6/1/2017 10:53:45 AM
Subject: Notice of EPA Award: 83587201-3
Assistance Agreement RD-83587201-3.pdf

...
,,,

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

OFFICE OF

ADMINISTRATION

AND RESOURCE

MANAGEMENT

Re: Notice of EPA Assistance Award

Dear Authorized Representative:

Attached is your Notice of Award from the U.S. Environmental Protection Agency. **Please carefully review the assistance agreement and <u>all</u> of the terms and conditions.**

Please make a copy for your records and provide the appropriate copies within your organization (page three of the award package intentionally left blank). The recipient's signature is not required on the enclosed agreement in order to signify acceptance. Award recipients demonstrate acceptance of the award and commitment to carry out the award by either: 1) drawing down funds within 21 calendar days after the mailing date indicated on the face page of the award; or 2) not filing a notice of disagreement with the award terms and conditions within 21 calendar days after the mailing date indicated on the face page of the award. The terms and conditions of some awards require additional signed certifications or assurances. These should be scanned and emailed to the EPA Grants Specialist listed on the face page of the award document. To file a notice of disagreement with the terms and conditions, the authorized representative of the recipient may also contact the Grants Specialist via email. Alternatively, hard copies of documents or correspondence may be sent to one of the addresses below:

For regular postal delivery: For courier or Federal Express delivery:

U.S. Environmental Protection Agency U.S. Environmental Protection Agency
Office of Grants and Debarment Office of Grants and Debarment

1200 Pennsylvania Avenue, NW (3903R) 1300 Pennsylvania Avenue, NW
Fifth Floor, Room 51234 Fifth Floor, Room 51234

Washington, DC 20460 Washington, DC 20004

Payment will be made available after any required certifications and/or assurances are received, if applicable. EPA's Las Vegas Finance Center will provide information about how you will receive payment and report on your financial transactions during the period of performance.

Guidance, regulations and additional forms needed throughout the life of your award are located at https://www.epa.gov/grants/grant-regulations-and-forms-new-grantees. You may refer to the terms and conditions of your award for guidance on completing and submitting all forms requested or required.

Please pay particular attention to the following items that are procedural changes contained in EPA's Online General Terms and Conditions linked directly to within the Administrative Terms and Conditions of this award. Take note of the "Award Date," also listed on the award document face page, which corresponds to a set of online conditions unique to a specific period in time that apply to your individual award:

∀ ***SF-425: FEDERAL FINANCIAL REPORTS (FFR) ANNUAL SUBMISSION:***

Any monetary action (new, incremental and supplemental) issued on or after **October 6, 2015** now requires EPA grant recipients to submit the SF-425: Federal Financial Report no later than 30 days after the end of each specified reporting period for quarterly and semi-annual reports, and 90 calendar days for annual and final reports. Extension of reporting due dates may be approved by EPA upon request of the recipient. The FFR form is available on the internet at: http://www2.epa.gov/financial/forms. All FFRs and manual payment requests (if not using ASAP) must be submitted to the Las Vegas Finance Center (LVFC) via email **LVFC-grants@epa.gov** or mail to:

USEPA LVFC

4220 S. Maryland Pkwy Bldg C, Suite 503

Las Vegas, NV 89119

Refer to the Online General Term and Condition titled: "Federal Financial Reporting" or "Final Federal Financial Report" as applicable.

∀ ***SUBAWARDS:***

As of **March 29, 2016**, the Office of Grants and Debarment issued the EPA Subaward Policy for EPA Assistance Agreements Recipients. Monetary actions (new, incremental and supplemental) issued after March 29 are subject to the subaward reporting requirements provisions of 2 CFR 200 and the EPA Subaward Policy. If your work plan and budget include subawards of financial assistance as defined in 2 CFR 200.92 and 2 CFR 200.330, EPA's National Term and Condition for Subawards titled: "Establishing and Managing Subawards" will apply.

By accepting this assistance agreement your organization is certifying that it either has systems in place to comply with the regulatory or EPA policy requirements specified in the National Term and Condition for Subawards, or that it will refrain from making subawards with funding EPA provides under this agreement until the systems are designed and implemented. Should your organization decide to make a subaward(s) that was not described in the work plan and budgeted for under this agreement, you must obtain prior written approval from EPA's Award Official as provided at 2 CFR 200.308(c)(1)(vi).

If you have any questions, please contact your Grants Specialist identified on the award document. Please reference the EPA assistance number on all future correspondence regarding this assistance agreement.

Attachment (Official EPA Award Document)

Jennifer Brooks

Grants Management Specialist

Environmental Protection Agency

Office of Grants and Debarment

202-564-6374

	U.S. ENVIRONMENTAL PROTECTION AGENCY **Assistance Amendment**	**GRANT NUMBER (FAIN):** 83587201 **MODIFICATION NUMBER:** 3 **PROGRAM CODE:** RD	**DATE OF AWARD** 05/23/2017
		TYPE OF ACTION Augmentation: Increase	**MAILING DATE** 05/30/2017
		PAYMENT METHOD: ACH	**ACH#** 0040

RECIPIENT TYPE: Private University	**Send Payment Request to:** Las Vegas Finance Center
RECIPIENT:	**PAYEE:**
Harvard School of Public Health 677 Huntington Ave Boston, MA 02115-6028 **EIN:** 04-2103580	Manager of Research Finance Harvard School of Public Health 1350 Massachusetts Avenue Cambridge, MA 02138-9998

PROJECT MANAGER	EPA PROJECT OFFICER	EPA GRANT SPECIALIST
Petros Koutrakis Harvard School of Public Health P.O. Box 15677; Landmark Center RM 410 A West Boston, MA 02215-9997 **E-Mail:** petros@hsph.harvard.edu **Phone:** 617-432-8469	Vito Ilacqua 1200 Pennsylvania Ave, NW, M315B Washington, DC 20460 **E-Mail:** Ilacqua.vito@Epa.gov **Phone:** 202-564-4512	Carl Davis 1200 Pennsylvania Ave NW Washington DC 20460, 3903R **E-Mail:** Davis.Carl@epa.gov **Phone:** 202-564-1864

PROJECT TITLE AND EXPLANATION OF CHANGES

Regional Air Pollution Mixtures: Past and Future Air Quality and Health

The center will investigate the sources, composition, trends, and effects of regional air pollutant mixtures across the US over a period spanning past and future years (2000- 2040), and will examine the influence of climate, socioeconomic factors, policy decisions , and control strategies on air pollution, human health and economic outcomes.

Incremental Amendment; This amendment provides incremental funding in the amount of $112,635.

BUDGET PERIOD	PROJECT PERIOD	TOTAL BUDGET PERIOD COST	TOTAL PROJECT PERIOD COST
12/01/2015 - 11/30/2020	12/01/2015 - 11/30/2020	$10,000,000.00	$10,000,000.00

NOTICE OF AWARD

Based on your Application dated 09/03/2014 including all modifications and amendments, the United States acting by and through the US Environmental Protection Agency (EPA) hereby awards $112,635. EPA agrees to cost-share 100.00% of all approved budget period costs incurred, up to and not exceeding total federal funding of $4,612,635. Recipient's signature is not required on this agreement. The recipient demonstrates its commitment to carry out this award by either: 1) drawing down funds within 21 days after the EPA award or amendment mailing date; or 2) not filing a notice of disagreement with the award terms and conditions within 21 days after the EPA award or amendment mailing date. If the recipient disagrees with the terms and conditions specified in this award, the authorized representative of the recipient must furnish a notice of disagreement to the EPA Award Official within 21 days after the EPA award or amendment mailing date. In case of disagreement, and until the disagreement is resolved, the recipient should not draw down on the funds provided by this award/amendment, and any costs incurred by the recipient are at its own risk. This agreement is subject to applicable EPA regulatory and statutory provisions, all terms and conditions of this agreement and any attachments.

ISSUING OFFICE (GRANTS MANAGEMENT OFFICE)	AWARD APPROVAL OFFICE
ORGANIZATION / ADDRESS	**ORGANIZATION / ADDRESS**
Grants and Interagency Agreement Management Division 1200 Pennsylvania Ave, NW Mail code 3903R Washington, DC 20460	Environmental Protection Agency Office of Research and Development 1200 Pennsylvania Ave, NW Washington, DC 20460

THE UNITED STATES OF AMERICA BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY

Digital signature applied by EPA Award Official for Jill D. Young - Chief - Grants Management Branch LaShaun Phillips - Award Official delegate	**DATE** 05/23/2017

EPA Funding Information

FUNDS	FORMER AWARD	THIS ACTION	AMENDED TOTAL
EPA Amount This Action	$ 4,500,000	$ 112,635	$ 4,612,635
EPA In-Kind Amount	$ 0	$	$ 0
Unexpended Prior Year Balance	$ 0	$	$ 0
Other Federal Funds	$ 0	$	$ 0
Recipient Contribution	$ 0	$	$ 0
State Contribution	$ 0	$	$ 0
Local Contribution	$ 0	$	$ 0
Other Contribution	$ 0	$	$ 0
Allowable Project Cost	$ 4,500,000	$ 112,635	$ 4,612,635

Assistance Program (CFDA)	Statutory Authority	Regulatory Authority
66.509 - Science to Achieve Results (STAR) Program	Clean Air Act: Sec. 103	2 CFR 200 2 CFR 1500 40 CFR 33 and 40 CFR 40

Fiscal

Site Name	Req No	FY	Approp. Code	Budget Organization	PRC	Object Class	Site/Project	Cost Organization	Obligation / Deobligation
-	1726T6G732	1718	C	26T6000	102FK6XR2	4141	-	26A6A	112,635
									112,635

Budget Summary Page

Table A - Object Class Category (Non-construction)	Total Approved Allowable Budget Period Cost
1. Personnel	$3,284,361
2. Fringe Benefits	$805,483
3. Travel	$102,250
4. Equipment	$15,000
5. Supplies	$171,500
6. Contractual	$197,500
7. Construction	$0
8. Other	$2,179,432
9. Total Direct Charges	$6,755,526
10. Indirect Costs: 61.50% Base MTDC	$3,244,474
11. Total (Share: Recipient 0.00 % Federal 100.00 %.)	$10,000,000
12. Total Approved Assistance Amount	$10,000,000
13. Program Income	$0
14. Total EPA Amount Awarded This Action	$112,635
15. Total EPA Amount Awarded To Date	$4,612,635

Administrative Conditions

A. **General Terms and Conditions**

The recipient agrees to comply with the current EPA general terms and conditions available at: https://www.epa.gov/grants/epa-general-terms-and-conditions-effective-october-3-2016-or-later. These terms and conditions are in addition to the assurances and certifications made as a part of the award and the terms, conditions, or restrictions cited throughout the award.

The EPA repository for the general terms and conditions by year can be found at http://www.epa.gov/grants/grant-terms-and-conditions.

B. In accordance with Section 2(d) of the Prompt Payment Act (P.L. 97-177), Federal funds may not be used by the recipient for the payment of interest penalties to contractors when bills are paid late nor may interest penalties be used to satisfy cost sharing requirements. Obligations to pay such interest penalties will not be obligations of the United States.

C. The recipient understands that none of the funds for this project (including funds contributed by the recipient as cost sharing) may be used to pay for the travel of Federal employees or for other costs associated with Federal participation in this project. Except however, if a Federal agency is selected through the recipient's procurement process to carry out some of the work as a contractor to the recipient, funds may be used to allow necessary Federal travel and other costs associated with Federal participation in this project.

D. EPA is partially funding this budget period and will consider funding the balance of the budget request contingent upon satisfactory progress as certified by the EPA Project Officer, the availability of funds, and EPA priorities. It is understood that the scope of work will be renegotiated to reflect the amount awarded if additional funds are not available.

E. Payment to consultants. EPA participation in the salary rate (excluding overhead) paid to individual consultants retained by recipients or by a recipient's contractors or subcontractors shall be limited to the maximum daily rate for a Level IV of the Executive Schedule (formerly GS-18), to be adjusted annually. This limit applies to consultation services of designated individuals with specialized skills who are paid at a daily or hourly rate. As of January 1, 2017, the limit is $620.56 per day and $77.57 per hour. This rate does not include transportation and subsistence costs for travel performed (the recipient will pay these in accordance with their normal travel reimbursement practices).

Subagreements with firms for services which are awarded using the procurement requirements in Subpart D of 2 CFR 200, are not affected by this limitation unless the terms of the contract provide the recipient with responsibility for the selection, direction and control of the individuals who will be providing services under the contract at an hourly or daily rate of compensation. See 2 CFR 1500.9.

All Other Administrative Conditions Remain the Same.

Programmatic Conditions

All Programmatic Conditions Remain the Same.

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Alice Smythe[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Mon 5/15/2017 2:16:43 PM
Subject: RE: ACE center grant monitoring

Hi Vito looking forward seeing you tomorrow

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Monday, May 15, 2017 10:03 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: ACE center grant monitoring

Dear Petros,

I'll be taking advantage of all the work you are putting into the SAC meeting to do a site visit for this year. This is just for your information, nothing is needed from you at this point. If need be, I'll follow up with additional questions. You'll receive a report later in the summer.

Looking forward to the meeting tomorrow

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

(202) 564 4512 | ilacqua.vito@epa.gov
National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:

Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Alice Smythe[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Hunt, Sherri
Sent: Mon 3/13/2017 11:08:52 PM
Subject: RE: Science Advisory Committee invitation

Great! I'm certain that his modeling expertise will be helpful.

Thanks.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, March 13, 2017 5:35 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Fwd: Science Advisory Committee invitation

Hi Sherri,

S.T. Rao has accepted our invitation to serve on our ACE Center SAC.

Thanks

Alice

Sent from my Virgin Mobile Phone.

-------- Original message --------

From: "S.T. Rao" <strao@ncsu.edu>

Date: 3/13/2017 4:21 PM (GMT-05:00)

To: "Smythe, Alice" <asmythe@hsph.harvard.edu>

Cc: "Koutrakis, Petros" <petros@hsph.harvard.edu>

Subject: Re: Science Advisory Committee invitation

Hello Alice and Petros,

Thanks for the invitation to be on your SAC. Yes, I'll plan on attending your meeting In mid May. Please send me the agenda and project information so I can be prepared for your meeting.

Regards,

ST

Sent from my iPad

S.T. Rao, Ph.D.

Editor-in-Chief, Journal of the Air & Waste Management Association

Google Scholar: https://scholar.google.com/citations?user=ngHmbQIAAAAJ&hl=en

Adjunct Professor, Department of Marine, Earth, and Atmospheric Sciences

North Carolina State University, Raleigh, NC 27695

E-mail: strao@ncsu.edu

and

Adjunct Professor, Department of Civil & Environmental Engineering

University of Connecticut, Storrs, CT 06269

E-mail: s.t.rao@uconn.edu

On Mar 13, 2017, at 3:47 PM, Smythe, Alice <asmythe@hsph.harvard.edu> wrote:

Dear Dr. Rao:

Petros asked me to contact you to invite you to serve as a committee member on the Science Advisory Committee of the USEPA Air, Climate and Energy Center (ACE). If you accept we also hope you will be available to participate in the SAC meeting which takes place in Boston on May 16 and 17. We apologize for not having issued this invitation sooner and for the short notice but we hope you will say yes to both joining the committee and to the meeting.

Thank you,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

https://content.sph.harvard.edu/ace/

To: Alice Smythe[asmythe@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 2/21/2017 3:29:01 PM
Subject: RE: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Hi Alice,

It's always uncertain when inviting speakers at that level. I'd suggest planning for her, but having a couple of ideas for back-ups who are people you know might be available or willing to fill in at the last minute. It's worth taking a chance since she would certainly be interesting.

You could suggest that a response be given by April 15 or May 1.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, February 20, 2017 4:05 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Hi Sherri and Vito,

We have formally invited Gina McCarthy to give the keynote talk at the Centers Annual Meeting June 1. Her response is below. Please advise us on whether you think we take the risk of penciling her into the agenda or if we rule her out since she doesn't seem able to commit at the moment, despite otherwise being willing. Petros is keen to have her but we'd like to have your input.

Thanks

Alice

From: McCarthy, Gina [mailto:Gina_McCarthy@hks.harvard.edu]
Sent: Friday, February 17, 2017 5:17 PM
To: Smythe, Alice
Subject: RE: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Alice – thank you for inviting me. I would be honored to do this but I am not sure at this point what the future may bring for me so it's hard to make a firm commitment. When do you need a know for sure? Can we talk then?

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Friday, February 17, 2017 3:11 PM
To: McCarthy, Gina <Gina_McCarthy@hks.harvard.edu>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Dear Dr. McCarthy,

I am contacting you at the request of Dr. Petros Koutrakis, Director of the Harvard/MIT Air, Climate & Energy (ACE) Center and Professor of Environmental Sciences at HSPH.

The annual ACE Centers meeting will take place on June 1 and 2 of 2017 in Cambridge, MA. As former EPA Administrator, the directors of the ACE centers would be very interested and honored, if you are available, to have you give the keynote address during lunch on June 1 to meeting attendees.

Please would you mind letting me know if you are available to do this on June 1, 2017.

Thank you very much,

Alice Smythe (Assistant to Petros Koutrakis)

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Alice Smythe[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Fri 2/17/2017 2:55:28 PM
Subject: RE: Next ACE Centers directors call

Hi Vito,

I am not sure if we need to do much

On my list is to invite Gina which I will do asap

The other outstanding issue is the occupancy of the rooms but this is something we cannot address now

I think if we can update the agenda and send it out to the group then we will not a meeting

However, I want to know if Alice thinks that we have outstanding issues which we need to address. In that case we will need a call

Have a nice weekend

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Friday, February 17, 2017 8:25 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Next ACE Centers directors call

Good morning Petros,

We are considering whether it is necessary to have the call next week. The planning for the annual meeting seems the most time-sensitive business, but there was not much discussion about it on the last call. Do you have a preference, or specific issues to be decided by the group? If you do, perhaps we may do so through email even if we don't hold a meeting, but we defer to you on this.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

(202) 564 4512 | ilacqua.vito@epa.gov
National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Alice Smythe[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Hunt, Sherri
Sent: Wed 2/1/2017 8:20:10 PM
Subject: RE: Another SAC Recommendation

Right – thanks for the reminder. I'll get to that later today.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, February 01, 2017 3:01 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Subject: RE: Another SAC Recommendation

Hi Sherri,

I will send him a formal invitation.

You'll recall you had managed to secure rooms in Boston for EPA folks at the government rate using a Federal employee site that I don't have access to. If possible, would you mind adding him?

Thank you!

Alice

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, February 01, 2017 2:46 PM
To: Smythe, Alice
Cc: Koutrakis, Petros; Ilacqua, Vito
Subject: Another SAC Recommendation

Hi Alice,

As Petros and I just discussed, here is the information for Scott Jenkins for invitation to the SAC meeting. Scott has formal training in Neurology and he is current acting as a science advisor in the Health and Environmental Effects Division of OAQPS. He will be helpful in commenting on how the work of the Center relates to the most current policy issues.

Jenkins.scott@Epa.gov

919-541-1167

Please let me know if you have any trouble contacting him.

Thanks very much to both of you.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Alice Smythe[asmythe@hsph.harvard.edu]
Cc: Petros Koutrakis[Petros@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Hunt, Sherri
Sent: Wed 2/1/2017 7:45:40 PM
Subject: Another SAC Recommendation

Hi Alice,

As Petros and I just discussed, here is the information for Scott Jenkins for invitation to the SAC meeting. Scott has formal training in Neurology and he is current acting as a science advisor in the Health and Environmental Effects Division of OAQPS. He will be helpful in commenting on how the work of the Center relates to the most current policy issues.

Jenkins.scott@Epa.gov

919-541-1167

Please let me know if you have any trouble contacting him.

Thanks very much to both of you.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Coull, Brent[bcoull@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]; Francis, Bradford[bfrancis@hsph.harvard.edu]; Lawrence, Joy[lawrence@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Tue 1/24/2017 9:18:02 PM
Subject: Re: Funding request for 2017

Thanks Vito
We will do
This will be for year three for ACE?
Correct?

Sent from my iPhone

On Jan 24, 2017, at 3:55 PM, Ilacqua, Vito <Ilacqua.Vito@epa.gov> wrote:

Good afternoon Petros,

I hope you had a successful trip. Notwithstanding what you may have read in the news, at the moment we are continuing at least the paperwork for next year's funding. Please do send me a request when possible.

Thank you

Vito

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Friday, December 30, 2016 1:47 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Francis, Bradford <bfrancis@hsph.harvard.edu>; Lawrence, Joy <lawrence@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: RE: Funding request for 2017

Hi Vito and happy new year. I am about to leave for china and korea and I will be away the next two weeks. However, Brad, Alice and Joy will take care of this. I will check my emails thought my trip.

Regards Petros

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Friday, December 30, 2016 1:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Funding request for 2017

Dear Petros,

When possible, please send me a request for another year of Center funding for 2017. This is the usual request on letterhead, indicating whether or not everything is proceeding satisfactorily, and whether these funds are needed for the project.

I will assume the previous budget still applies, but you can follow up with a revised one later, if appropriate.

Thank you and Happy 2017!

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

(202) 564 4512 | ilacqua.vito@epa.gov
National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Francis, Bradford[bfrancis@hsph.harvard.edu]; Lawrence, Joy[lawrence@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Fri 12/30/2016 6:46:40 PM
Subject: RE: Funding request for 2017

Hi Vito and happy new year. I am about to leave for china and korea and I will be away the next two weeks. However, Brad, Alice and Joy will take care of this. I will check my emails thought my trip.

Regards Petros

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Friday, December 30, 2016 1:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Funding request for 2017

Dear Petros,

When possible, please send me a request for another year of Center funding for 2017. This is the usual request on letterhead, indicating whether or not everything is proceeding satisfactorily, and whether these funds are needed for the project.

I will assume the previous budget still applies, but you can follow up with a revised one later, if appropriate.

Thank you and Happy 2017!

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Hunt, Sherri
Sent: Sat 4/1/2017 11:40:37 PM
Subject: RE: Letter to the Editor on our PNAS article

Thank you, Petros. When you learn the publication date, please let us know.

Yes – I plan to attend the HEI meeting – it's practically in my back yard. ☺ I hope that we can catch up.

All the best,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 11:37 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Subject: FW: Letter to the Editor on our PNAS article

FYI, confidential

Are you going to HEI meeting, if yes I am looking forward seeing you there

From: Baccarelli, Andrea [mailto:ab4303@cumc.columbia.edu]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Diane Gold <redrg@channing.harvard.edu>; Jia Zhong <jiazhong@mail.harvard.edu>
Subject: Letter to the Editor on our PNAS article

Hi Petros,

We received a letter sent by Lucock et al to the PNAS editor that is critical of our article.

We prepared (I need to say that Diane did most of the work) a response that is attached here.

Due to the sensitivity of the issue discussed, we would appreciate your review of our response. I am attaching the PDFs of our published article as well as of the letter submitted by Lucock et al.

Andrea

To: Hunt, Sherri[Hunt.Sherri@epa.gov]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Koutrakis, Petros
Sent: Mon 3/27/2017 3:37:03 PM
Subject: FW: Letter to the Editor on our PNAS article
Letter response dg_mvg_BU AAB dg.docx
PNAS-2017-Zhong-1618545114.pdf
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FYI, confidential

Are you going to HEI meeting, if yes I am looking forward seeing you there

From: Baccarelli, Andrea [mailto:ab4303@cumc.columbia.edu]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Diane Gold <redrg@channing.harvard.edu>; Jia Zhong <jiazhong@mail.harvard.edu>
Subject: Letter to the Editor on our PNAS article

Hi Petros,

We received a letter sent by Lucock et al to the PNAS editor that is critical of our article.

We prepared (I need to say that Diane did most of the work) a response that is attached here.

Due to the sensitivity of the issue discussed, we would appreciate your review of our response. I am attaching the PDFs of our published article as well as of the letter submitted by Lucock et al.

Andrea

B vitamins attenuate the epigenetic effects of ambient fine particles in a pilot human intervention trial

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Edited by Kirk R. Smith, University of California, Berkeley, CA, and approved February 13, 2017 (received for review November 8, 2016)

Acute exposure to fine particle ($PM_{2.5}$) induces DNA methylation changes implicated in inflammation and oxidative stress. We conducted a crossover trial to determine whether B-vitamin supplementation averts such changes. Ten healthy adults blindly received a 2-h, controlled-exposure experiment to sham under placebo, $PM_{2.5}$ (250 μg/m^3) under placebo, and $PM_{2.5}$ (250 μg/m^3) under B-vitamin supplementation (2.5 mg/d folic acid, 50 mg/d vitamin B_6, and 1 mg/d vitamin B_{12}), respectively. We profiled epigenome-wide methylation before and after each experiment using the Infinium HumanMethylation450 BeadChip in peripheral CD4$^+$ T-helper cells. $PM_{2.5}$ induced methylation changes in genes involved in mitochondrial oxidative energy metabolism. B-vitamin supplementation prevented these changes. Likewise, $PM_{2.5}$ depleted 11.1% [95% confidence interval (CI), 0.4%, 21.7%; P = 0.04] of mitochondrial DNA content compared with sham, and B-vitamin supplementation attenuated the $PM_{2.5}$ effect by 102% ($P_{interaction}$ = 0.01). Our study indicates that individual-level prevention may be used to complement regulations and control potential mechanistic pathways underlying the adverse $PM_{2.5}$ effects, with possible significant public health benefit in areas with frequent $PM_{2.5}$ peaks.

air pollution | B vitamins | DNA methylation | mitochondria

Historical episodes of air pollution peaks were shown to be associated with up to >10 times increased death rates (1). According to the WHO, 92% of the world's population currently lives in places where air quality levels exceed the WHO limits (2). Ambient $PM_{2.5}$ (particles with an aerodynamic diameter of <2.5 μm) pollution is one of the most prominent air pollutants (3), because they deposit in the respiratory bronchioles and the alveoli and stimulate local and systemic inflammation and oxidative stress (4). Over the past few decades, substantial lowering of ambient $PM_{2.5}$ levels has been achieved through large-scale emissions control policies (5). However, exposure peaks with adverse health consequences are still frequently recorded (6, 7), even in areas typically exhibiting low levels (5). The molecular mechanisms underlying $PM_{2.5}$'s health effects are not fully understood, and the lack of preventative options at the individual level adds complexity to tackling this major public health challenge.

Recent studies in environmental epigenetics provide opportunities to understand the mechanistic underpinnings of exposure-related health effects and to develop novel individual-level interventions. DNA methylation, a potentially modifiable epigenetic mechanism, can regulate gene expression and chromosome integrity via addition of methyl groups to cytosine residues (8). The dynamic DNA landscape can be rapidly altered in peripheral leukocytes following $PM_{2.5}$ exposure; indeed, such changes are postulated to underlie PM-induced systemic inflammation and oxidative stress (9, 10). Most evidence of this phenomenon in humans is based on a heterogeneous mixture of leukocytes (9–12), but a loss of methylation in inflammatory genes and subsequent inflammatory responses, specifically in circulating Th cells, are observed in vivo after environmental challenge (13, 14). Notably, DNA methylation is dependent on a biochemical cycle that supplies methyl groups (CH_3) while relying on methyl nutrients (i.e., B vitamins including folic acid, vitamin B_6 and B_{12}; and amino acids including methionine, betaine, and choline) (8, 15, 16). In animal studies, a methyl-nutrient-deficient diet leads to aberrant DNA methylation patterns (17), and administration of methyl nutrients enables restoration of epigenetic status (15, 18–20). Likewise, human studies show that dietary methyl nutrient intervention influences the plasticity of DNA methylation (21). The potential for epigenetic modulation has also been demonstrated in the presence of environmental stressors in animal models—Dolinoy et al. successfully used methyl nutrients to avert the DNA hypomethylation induced by bisphenol A exposure (22). These findings

Significance

Air pollution is a major public health concern worldwide. The molecular mechanistic underpinnings of the health effects of air pollution are not fully understood, and the lack of individual-level preventative options represent a critical knowledge gap. Our study demonstrated the epigenetic effects of air pollution and suggested that B vitamins might be used as prevention to complement regulations to attenuate the impact of air pollution on the epigenome. Our study inaugurated a line of research for the development of preventive interventions to minimize the adverse effects of air pollution on potential mechanistic markers. Because of the central role of epigenetic modifications in mediating environmental effects, our findings might be extended to other toxicants and environmental diseases.

Author contributions: J.Z., P.K., F.S., D.R.G., and A.A.B. designed research; J.Z., O.K., G.W., B.U., and M.S. performed research; J.Z., O.K., G.W., J.L., X.L., M.Z., M.S.-G., L.T., M.S., L.L., B.A.C., and T.W. contributed new reagents/analytic tools; J.L. and T.W. provided the replication dataset for revision; X.L. advised epigenome-wide analysis; L.T. served as data manager; L.L. and B.A.C. advised biostatistics; P.K. designed the exposure devices; J.Z. and Y.G. analyzed data; and J.Z. wrote the paper.

The authors declare no conflict of interest.

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opened new avenues for the application of epigenetic intervention to reduce the health effects of air pollution. However, to date, epigenetic intervention in humans in the context of air pollution has not been described.

The present study is a placebo-controlled crossover pilot intervention trial with controlled human exposure experiments to concentrated ambient fine particles ($PM_{2.5}$). We hypothesized that acute $PM_{2.5}$ exposure can rapidly modify the DNA methylation profile in peripheral $CD4^+$ Th cells—the most prolific cytokine producer mediating $PM_{2.5}$-induced inflammatory responses—and that $PM_{2.5}$-induced DNA methylation changes can be reduced by B vitamins (i.e., folic acid, vitamin B_6, and B_{12}), the primary source of methyl groups (Fig. 1).

Results

Study Population, Plasma B-Vitamin Concentrations, and Exposure Levels. In the present crossover placebo-controlled trial, 10 volunteers completed 30 controlled exposure experiments following the same order (Fig. S1): seven volunteers aged 19–29 y and three aged 30–49 y. Four volunteers were white, three were Asian, and three were other races. Six volunteers were female and three volunteers had a body mass index (BMI) ≥25. All volunteers maintained consistent dietary patterns throughout the trial.

The targeted concentration of $PM_{2.5}$ exposures was 250 μg/m^3. However, the actual $PM_{2.5}$ concentrations varied among controlled exposure experiments to $PM_{2.5}$ (100.6–287.5 μg/m^3; median: 234.0 μg/m^3). There was no significant difference ($P = 0.38$) in $PM_{2.5}$ concentration between $PM_{2.5}$ experiment under placebo [median: 219.1 μg/m^3; interquartile range (IQR): 33.1 μg/m^3] and $PM_{2.5}$ experiment under B vitamins (median: 237.2 μg/m^3; IQR: 48.7 μg/m^3).

To confirm that supplementation affected circulating nutrient levels, we measured plasma B vitamins before and after placebo and supplementation. The median plasma concentrations of folic acid and vitamins B_6 and B_{12} were 35 nmol/L (IQR: 14 nmol/L), 41 nmol/L (IQR: 16 nmol/L), and 292 pmol/L (IQR: 72 pmol/L) before sham experiment, respectively. After volunteers took placebos for 4 wk, their median plasma concentrations were similar: 39 nmol/L (IQR: 24 nmol/L) for folic acid ($P = 0.82$), 37 nmol/L (IQR: 18 nmol/L) for vitamin B_6 ($P = 0.75$), and 262 pmol/L (IQR: 214 pmol/L) for vitamin B_{12} ($P = 0.42$). B-vitamin supplementation significantly increased the median plasma concentrations of folic acid (56 nmol/L; IQR: 13; $P = 0.02$), vitamin B_6 (428 nmol/L; IQR: 321; $P = 0.004$), and vitamin B_{12} (511 pmol/L; IQR: 85; $P = 0.01$). The abovementioned P values were based on Wilcoxon signed-rank test, a nonparametric paired difference test.

$CD4^+$ Th Cell Purity. All $CD4^+$ Th cell samples' purity were over 80% (Table S1), with only minor contamination from CD8 T cells, B cells, granulocytes, and natural killer cells. The median purity of samples collected at sham experiment, $PM_{2.5}$ experiment under placebo, and $PM_{2.5}$ experiment under B vitamins was 96.9% (IQR: 5.1), 94.8% (IQR: 7.1), and 96.1% (IQR: 4.7), respectively.

Effect of $PM_{2.5}$ and B-Vitamin Supplementation on DNA Methylation. Two-hour $PM_{2.5}$ exposure substantially modified DNA methylation in $CD4^+$ Th cells, and these changes were prevented by B-vitamin supplementation (Fig. 2). Because our study is limited in power, we present only the top 10 loci, selected following the method proposed by Maccani et al. (23)—first based on effect size and then P value (Table S2 and Fig. 2A). In the absence of B-vitamin supplementation, $PM_{2.5}$ exposure either increased or decreased DNA methylation levels, compared with sham, at these loci (Fig. 2A). Quantile-Quantile plots for expected vs. observed distribution of P values showed minimal genomic inflation with a lambda of 1.03 (Fig. 2B).

Table S2 presents the genomic position, relation to CpG islands, and gene symbol for the 10 loci. The top two loci that are associated with known genes were cg06194186 and cg17157498. Locus cg06194186 is located in the promoter region (TSS1500) of the carboxypeptidase O (CPO) gene, and locus cg17157498 is located in the promoter region (TSS1500) of the NADH dehydrogenase (ubiquinone) Fe-S protein 7 (NDUFS7) gene (Figs. S2 and S3). Fig. 3 presents the shift in methylation level distributions and corresponding IQRs pre and post each exposure experiment for these two loci.

Four-week B-vitamin supplementation attenuated the $PM_{2.5}$ effect by 28–76% at the top 10 loci. Supplementing B vitamins resulted in a reduction in effect size by 57% for cg06194186, 49% for cg07689821, 73% for cg00068102, 31% for cg00647528, 45% for cg15426626, 28% for cg10719920, 76% for cg21986027, 74% for cg17157498, 63% for cg08075528, and 71% for cg26995744, respectively (Table S3 and Fig. 2C).

Effect of $PM_{2.5}$ and B-Vitamin Supplementation on Mitochondrial DNA Content. CPO and NDUFS7 are both involved in mitochondrial oxidative energy metabolism—a pivotal function with substantial impact on mitochondrial biogenesis and clearance (24, 25). In the secondary exploratory analysis, we further tested the associations of $PM_{2.5}$ with mitochondrial DNA content, as well as the potential protective effect of B-vitamin supplementation. In the absence of B-vitamin supplementation, compared with sham, 2-h exposure to $PM_{2.5}$ was estimated to be nonsignificantly associated with a −0.3% change [95% confidence interval (CI): −10.1%, 9.5%; $P = 0.94$] in mitochondrial DNA content. However, 24 h after exposure experiments, we observed substantial reduction in mitochondrial DNA content associated with $PM_{2.5}$: 2-h exposure to $PM_{2.5}$ significantly depleted mitochondrial DNA content by 11.1% (95% CI: 0.4%,

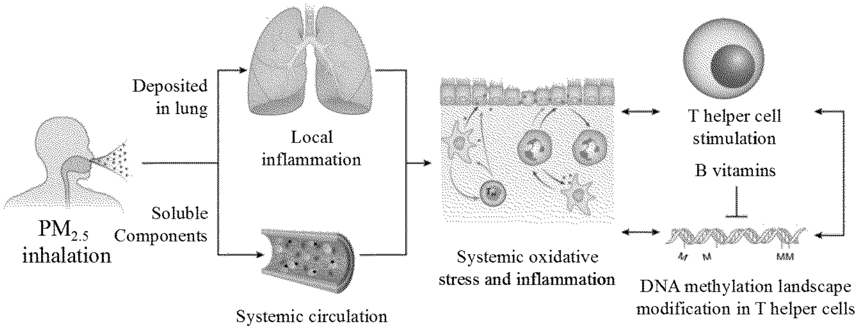

Fig. 1. Proposed conceptual model linking fine particulate matter ($PM_{2.5}$), systemic oxidative stress and inflammation, and altered DNA methylation landscape in Th cells. We hypothesized that $PM_{2.5}$ inhalation triggers local and systemic inflammation and oxidative stress, which alters the DNA methylation landscape in circulating $CD4^+$ Th cells and further stimulates $CD4^+$ Th cells. In return, stimulated $CD4^+$ Th cells undergo more epigenetic remodeling—possibly due to modulated methyl group availability—therefore creating a vicious circle which amplifies the inflammatory and oxidative effects of $PM_{2.5}$.

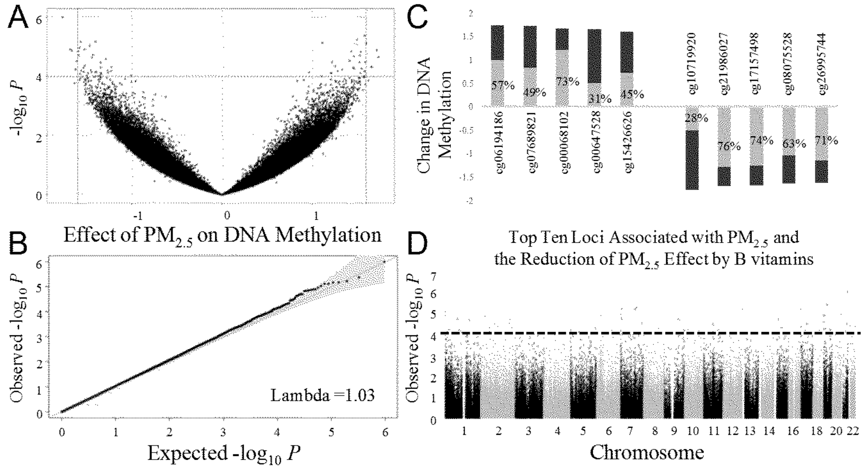

Fig. 2. The effect of 2-h exposure to $PM_{2.5}$ on DNA methylation landscape and the reduction of $PM_{2.5}$ effect by B-vitamin supplementation. A is the Volcano plot depicting the distribution of estimated effect of $PM_{2.5}$ exposure on the epigenome. Each dot represents the estimated $PM_{2.5}$ effect for one CpG. The vertical lines indicate suggestive threshold based on effect size, whereas the horizontal line reflects the suggestive threshold based on statistical significance. B is the quantile–quantile plot for associations of $PM_{2.5}$ with DNA methylation in circulating $CD4^+$ Th cells. C represents the top 10 loci associated with $PM_{2.5}$ and the reduction of $PM_{2.5}$ effect by B vitamins. Bar height indicates $PM_{2.5}$ effect, whereas the gray part indicates the magnitude of effect attenuation by B vitamins. D is the Manhattan plot representing the chromosome location of each loci. The dashed horizontal line reflects the suggestive threshold for statistical significance. Analyses were adjusted for season, chamber humidity, and temperature.

21.7%; P = 0.04) (Table S3). B-vitamin supplementation completely attenuated such effect of $PM_{2.5}$ by 102% ($P_{interaction}$ = 0.01). With B-vitamin supplementation, 2-h exposure to $PM_{2.5}$ was not associated with mitochondrial DNA content (0.2%; 95% CI: −8.3%, 8.8%; P = 0.96) (Table S3).

Exploratory Mediation Analysis and External Supporting Data. We further deconstructed total $PM_{2.5}$ effects on mitochondrial DNA content into direct and indirect (i.e., mediated) effects to investigate whether DNA methylation levels at loci cg06194186 and cg17157498 mediate $PM_{2.5}$–mitochondrial DNA content relationship. Our result indicated that 16.0% (95% CI: 4.1%, 27.9%) and 18.4% (95% CI: 9.9%, 26.9%) of the PM effect on mitochondrial DNA content was mediated by cg06194186 and cg17157498 methylation, respectively. Consistent with our hypothesis, we observed correlation between mitochondrial DNA content and the methylation levels of cg06194186 (r = −0.45; P = 0.06) and cg17157498 (r = 0.63; P = 0.01) in $CD4^+$ Th cells, in an independent external dataset.

Sensitivity Analysis. B vitamins have a long biological half-life (26), therefore requires a washout period longer than four months. We designed the trial without randomizing the treatment order (placebo vs. B vitamins) to avoid long washout periods, which would have made exposure experiments on the same volunteer less comparable. Lifestyle factors may vary over several months, particularly in relation to seasonality, which also may directly affect DNA methylation (8, 10). To rule out the potential impact of temporal trend on our results, we adjusted for date-since-entry, and this adjustment did not affect our conclusion. Furthermore, we conducted permutation test on the two top loci to ensure the robustness of our analysis ($P_{permulation}$ < 0.001). In the analysis involving the mitochondrial DNA content, we additionally adjusted for age (continuous), BMI (continuous), and race (categorical) to examine if our results are

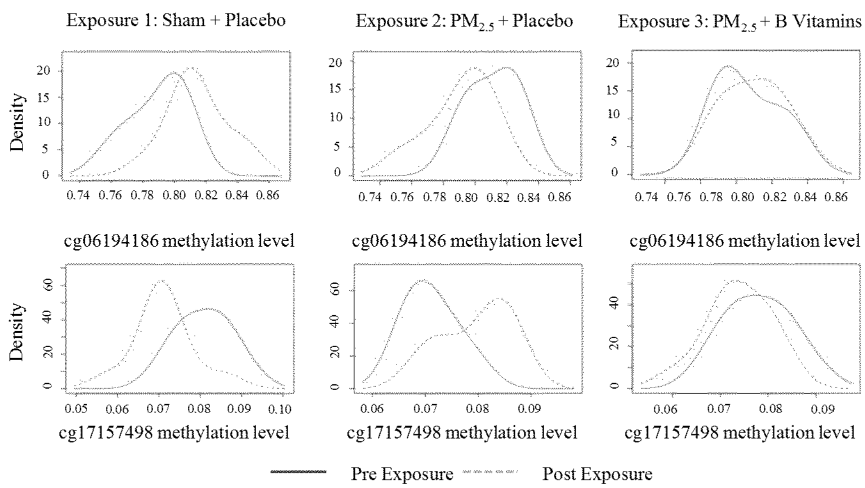

Fig. 3. Distribution of DNA methylation levels of cg06194186 and cg17157498 before and after each exposure experiment. Red solid lines and green dashed lines indicate the distribution of methylation levels measured before and after exposure, respectively.

sensitive to covariates specification. Our results were robust and consistent (Table S3).

Discussion

This crossover intervention trial with controlled exposure experiments demonstrated that 2-h exposure to concentrated ambient $PM_{2.5}$ (250 μg/m^3) affects the dynamic epigenetic landscape in circulating $CD4^+$ Th cells among healthy adults. We showed that these effects can be prevented with B-vitamin supplementation (i.e., folic acid and vitamins B_6 and B_{12}). Furthermore—as the top loci suggested potential modulation of mitochondrial metabolism—we followed up these findings by showing that exposure to $PM_{2.5}$ significantly altered mitochondrial DNA content in circulating $CD4^+$ Th cells, and B-vitamin supplementation nearly completely prevented these effects.

Air pollution has been consistently associated with adverse health outcomes in epidemiological studies (1, 3, 4, 9). Although the biological mechanism underlying the health effects of $PM_{2.5}$ remains not fully understood, systemic inflammation and oxidative stress have been proposed as essential biological pathways (4, 27). Furthermore, $PM_{2.5}$ can disturb DNA methylation profiles (9, 10, 13), which might exacerbate oxidative and inflammatory responses following exposure. A previous human exposure study demonstrated that Toll-like receptor 4 (TLR4) gene hypomethylation in leukocytes mediates a part of PM effect on blood pressure (28). Recently, an epigenome-wide association study (EWAS) showed that low-concentration air pollution alters DNA methylation profiles in whole blood (9). However, the interpretation of those findings is limited, considering potential bias due to cell-type heterogeneity within whole blood, and by the correlational nature of observational studies (11, 12). In addition, these findings might not be generalizable to areas with frequent air pollution peaks. The present study—a cell type-specific EWAS using controlled exposure experiments—has the unique advantage of providing unbiased insight on the novel epigenetic underpinnings of the proinflammatory and prooxidative effects of $PM_{2.5}$ exposure peaks.

In line with our hypothesis, we demonstrated acute effects of $PM_{2.5}$ inhalation on DNA methylation in the promoter region of genes related to mitochondrial function and oxidative metabolism (24, 25): CPO, a member of the metalloenzyme family (25), is involved in metal ion binding, metallopeptidase, and metallocarboxypeptidase activities—which are essential in regulation of the steady-state concentration of O_2^- in the intermembrane space of mitochondria (29); NDUFS7 encodes one of the subunits of the mitochondrial respiratory chain complex I that transfers electrons from NADH to coenzyme Q, and NDUFS7 mutations were of etiological significance in mitochondrial complex I deficiency (30). Although mitochondria have their own genetic material distinct from the nuclear DNA, the majority of mitochondrial proteins are encoded by the nuclear genome (31). The observation that $PM_{2.5}$ exposure substantially altered DNA methylation of nuclear genes in mitochondrial pathways indicate that mitochondria—the specialized organelles that regulate cellular-redox-balance and supplies energy—are a primary target of PM-induced cellular responses (32).

Our results on mitochondrial DNA content supplemented the findings from the epigenome-wide DNA methylation scan: exposure to $PM_{2.5}$ for 2 h was followed by reduced mitochondrial DNA content 24-h postexposure. The cellular mitochondrial genomic content is stringently regulated by biogenesis/degradation machinery (33), which is vital in the determination of cell survival and function. Compensatory mitochondria biogenesis can buffer an intracellular reactive oxygen species (ROS) challenge, as an adaptive stress response to eliminate cellular oxidative damage (34). However, persistent oxidative stress may eventually overwhelm the adaptive response system and lead to mitochondrial DNA depletion via mitophagy (35). Our results support this hypothesis by demonstrating that exposure to high-concentration $PM_{2.5}$ can reduce the mitochondrial DNA contents in circulating $CD4^+$ Th cells. Consistent with our results, a recent study reported that a 10 μg/m^3 increase in coarse PM ($PM_{10-2.5}$) exposure during pregnancy was associated with a 16.1% decrease in placental mitochondrial DNA content (36). Our exploratory mediation analysis indicates that short-term exposure to high-concentration $PM_{2.5}$ depletes mitochondrial DNA content, likely via—at least in part—modulating DNA methylation levels of genes in mitochondrial pathways. Future studies are warranted to investigate the potential for targeted epigenetic interventions.

DNA methylation is a modifiable biochemical process relying on methyl-group supplying nutrients such as B vitamins, which is postulated to increase DNA methylation levels (8, 15, 16). This feature renders B-vitamin supplementation an attractive pharmaceutical intervention to counteract the PM effects, which has been associated with loss of DNA methylation on inflammatory genes (28). Landmark experiments on the Agouti A^{vy} mice and other models have shown that dietary methyl nutrients, added during gestation (15–18) or later even in adult life (20, 21), can be used to modulate DNA methylation status. In human studies, intake of a folic acid-depleted diet for several weeks promotes hypomethylation of lymphocyte genomic DNA among postmenopausal women, and this hypomethylation is reversible with folic acid replacement (21). Among patients with colorectal adenomatous polyps, folic acid supplementation led to a 31% increase in leukocyte DNA methylation and a 25% increase in DNA from the colonic mucosa (37). Potential for human translation is also demonstrated in animal models, as methyl group-supplying nutrients can be used to prevent the loss of DNA methylation induced by environmental pollutants in rodents (22). However, to the best of our knowledge, whether B vitamins can be used to limit adverse effects from PM pollution has not previously been tested in human. Our research provided the experimental evidence showing that the epigenetic effects of $PM_{2.5}$ can be reduced using 4-wk B-vitamin supplementation. Remarkably, in our data, the B-vitamin supplementation not only prevented decreased DNA methylation but also increased DNA methylation following acute exposure to high-concentration PM. These findings suggest that B vitamins might protect against DNA hypomethylation as methyl group-supplying nutrients. On the other hand, B vitamins might also minimize DNA hypermethylation through interactions with regulatory pathways mediated by essential enzymes (such as DNA methyltransferases and methylenetetrahydrofolatereductase).

A major innovation of the present study over previous human epigenome-wide studies is the use of isolated $CD4^+$ Th cells—an essential cell type modulating human immunity through both its own immune activities and regulation of other leukocytes' proliferation, apoptosis, migration, and other functions via cytokine signaling (31). Therefore, the epigenetic effects of $PM_{2.5}$ and protective effects of B vitamins observed in $CD4^+$ Th genome might indicate subsequent modulation of essential cellular functions of other blood cell types. The Houseman cell proportion estimates indicated high purity of the analyzed samples. Although our study is subject to residual influence from differential $CD4^+$ Th subsets, the observed effect of $PM_{2.5}$ or B vitamins on DNA methylation is unlikely to be surrogate for leukocyte composition variation. Our plating scheme for DNA methylation analysis is independent of the exposure and treatment status, and was designed to minimize potential bias due to technical variables. Thus, the measurement error of DNA methylation can be assumed to be nondifferential and, therefore, likely to bias the results toward null. We conducted sensitivity analysis to robustly evaluate the impact of $PM_{2.5}$ on top loci, and further supported the EWAS results with a widely accepted mitochondrial marker—mitochondrial DNA content—with a highly reproducible quantitative real-time PCR method. Our crossover design controlled for time-invariant factors such as sex, race, BMI, SNP, etc. In addition, all exposure experiments were conducted at the same time of the day to eliminate any impact due to diurnal variation.

We acknowledge several limitations in the present pilot study. Although our EWAS is limited in power to meet the stringent Bonferroni threshold for significance with only 10 volunteers (30 exposure experiments), our sample size is comparable to previous controlled exposure studies that succeeded in demonstrating health effects of PM exposure (28, 38–40). As suggested by previous study (23), we selected the top loci based on both effect size and statistical significance, because those loci are more likely to infer biological significance. The short study duration was implemented to reduce the impact of with-in volunteer seasonal variations. Therefore, we could not randomize on the treatment (placebo vs. B vitamins) order due to long biological half-life of body stores of B vitamins (26), which might create potential confounding due to a temporal trend or learning effect (i.e., the volunteers might be more tolerant with the $PM_{2.5}$ effects at the second $PM_{2.5}$ exposure). In the sensitivity analysis, we adjusted for the amount of time passing because the study entry, and our results were consistent. Although residual confounding is possible, considering the magnitude of our effect estimates and the consistency of our findings, it is unlikely that the observed association reflected bias resulting from confounding. In addition, actual $PM_{2.5}$ concentration in $PM_{2.5}$ experiments under placebo was nonsignificantly lower than $PM_{2.5}$ experiments under B-vitamin supplementation, which might bias our results on B vitamins' protective effects toward the null. Finally, future validation studies are warranted because our unique study design using $CD4^+$ Th cells created major challenge to identify a suitable replication cohort, and our findings might not be generalizable to other cell types due to cell-type specificity of DNA methylation and mitochondrial DNA content.

The unclear molecular mechanistic underpinning of $PM_{2.5}$'s health effects remains the major gap in current knowledge—thereby creating challenges in developing preventative strategies. The present study is a pilot intervention trial in the investigation of mechanistic pathways underlying the adverse health effects of air pollution, and potential targeted preventive approaches. We demonstrated that ambient $PM_{2.5}$ exposure peak has unfavorable effects on epigenetic and pro-oxidative markers that can be neutralized by B-vitamin supplementation. Our findings suggest promising opportunities to aid the development of novel intervention strategies—which is particularly important for pathologies related to ubiquitous exposures such as $PM_{2.5}$ pollution. Future trials with larger sample sizes are warranted to shed light on the precise pathophysiological processes of PM-induced inflammatory and oxidative responses, the mechanism underlying the protective effect of B vitamins, and potential clinical application.

Methods

Study Population. We recruited 10 healthy, 18- to 60-y-old, nonsmoking volunteers who were not taking any medicines or vitamin supplements, from the University of Toronto campus and surrounding area. The trial protocols were approved by all participating institutional review board (University of Toronto, St. Michael's Hospital, and Harvard T.H. Chan School of Public Health) and registered (ClinicalTrials.gov identifier NCT01864824; date of registration: May 8, 2013). All methods were performed in accordance with the relevant guidelines and regulations. We obtained written informed consent from every volunteer before enrollment.

Study Design. We conducted a single-blind, crossover intervention trial with controlled exposure experiments to concentrated ambient $PM_{2.5}$ (July 2013 to February 2014). The design (Fig. 1) started with a 2-wk run-in period with placebo, followed by the baseline sham experiment (2 h, particle-free medical air, exposure one). After sham experiment, each volunteer took placebo for 4 wk and was then exposed to $PM_{2.5}$ (2 h, target concentration: 250 μg/m^3, exposure two). Volunteers started the 4-wk B-vitamin supplementation after exposure two, and then were exposed again to $PM_{2.5}$ (2 h, target concentration: 250 μg/m^3, exposure three). All volunteers received three exposure experiments following the same order.

Exposure Facility. Ambient particles were drawn in from an inlet 1.5 m high, beside a busy (>1,000 vehicles per hour) street in downtown Toronto. We used the Harvard ambient particle concentrator to generate concentrated ambient $PM_{2.5}$ (41), and delivered $PM_{2.5}$ air stream to the volunteer seated inside a 4.9-m^3 (1.1 × 1.9 × 2.0 m) lexan enclosure via an "oxygen type" facemask. The sham exposure with medical air were generated as previously described (38). During each exposure experiment, $PM_{2.5}$ mass was collected on a 47-mm, 2-μm Teflon filter (Teflo, R2PJ047; Pall Corp.) and was monitored using the gravimetric determination of $PM_{2.5}$ exposure mass concentration (micrograms per cubic meter).

Folic Acid, Vitamin B_6, and Vitamin B_{12} Supplement. We administered one placebo or B-vitamin supplement (2.5 mg of folic acid, 50 mg of vitamin B_6, and 1 mg of vitamin B_{12}) daily to each volunteer. Previous human trials showed that these doses rapidly increased plasma B-vitamin levels, modified methyl-cycle metabolite levels, and ameliorated cardiovascular measurements (42, 43). Preparation, packaging, and coding of the placebo and supplement were done by an external laboratory (Jamieson Laboratories) and was blinded to the volunteers. Before each exposure experiment, we measured volunteers' plasma folic acid and vitamin B_{12} levels using competitive-binding immunoenzymatic assay (A98032 and 33000; Beckman Coulter), and vitamin B_{12} levels using HPLC with fluorescence detection. At the first and the last visit, we assessed typical daily B-vitamin intake with a self-administered validated (44), semiquantitative food-frequency questionnaire used in the Nurses' Health Study.

$CD4^+$ Th Cell Isolation and DNA Extraction. We collected blood samples via venous phlebotomy (preexposure, immediately postexposure, and 24 h postexposure), and within 4 h, isolated $CD4^+$ Th cells by removing unwanted cells using RosetteSep Human $CD4^+$ T Cell Enrichment Mixture (no. 15062; Stem Cell Technologies). DNA was then extracted using a Promega Maxwell 16 instrument with tissue DNA purification kit (Promega). We monitored the concentration and quality of extracted DNA using NanoDrop ND-1000 spectrophotometer (Nanodrop Technologies). Unsatisfactory DNA samples were discarded and DNA was extracted again. We estimated the proportions of major leukocyte types (CD4 T cells, CD8 T cells, B cells, granulocytes, monocytes, and natural killer cells) to assess the purity of isolated $CD4^+$ Th cells using the Houseman method, a statistical deconvolution technique based on the 450K data (11).

Epigenome-Wide DNA Methylation Scan. We measured the epigenome-wide DNA methylation profile using the Infinium Human Methylation 450K BeadChip (Illumina) (45), which allows the assessment of approximately half a million CpG sites across 99% of RefSeq genes within the genome (46). Because of the within-volunteer, cross-over design, we plated all samples from one volunteer in one chip, with pre- and postexposure samples randomly loaded onto each column on the same row. All samples were processed by one technician and analyzed in one batch to minimize batch effect. Sample preparation and quality control details are explained in SI Methods.

Mitochondrial DNA Content in $CD4^+$ Th Cells. We measured mitochondrial DNA content in $CD4^+$ Th cells through the mtDNA/nDNA ratio, a widely used biomarker representing the mitochondrial DNA copy number versus the nuclear DNA copy number (34). Mitochondrial DNA copy number was analyzed pre, immediately after, and 24 h after each exposure experiment using multiplex quantitative real-time PCR, as previously reported (34). The mtDNA/nDNA is used in the statistical analysis—a ratio value of 1 indicates that the mtDNA/nDNA of the test sample is equal to the mtDNA/nDNA in the reference DNA pool used in the assay.

$CD4^+$ Th Mitochondrial DNA Content and DNA Methylation in External Dataset. To strengthen our findings, we identified an external dataset based on 15 deidentified volunteers' $CD4^+$ T cells—which were purified from fresh blood samples through magnetic-activated cell sorting using anti-CD4 antibody coupled paramagnetic microbeads (Miltenyi Biotec). Epigenome-wide DNA methylation profiles and mitochondrial DNA content were measured using the same methods of the present study.

Statistical Methods. We used linear mixed-effects models (SI Methods) with random intercepts assigned to each volunteer to account for correlation among within-volunteer measurements. The crossover design minimized the influence from time-invariant factors. In all models, we adjusted for time-varying covariates with potential influences on DNA methylation, selected based on prior knowledge and the existing literature [i.e., season (fall/winter/spring/summer), chamber temperature, and chamber relative humidity (38)]. Rank-based normal transformation was performed on all DNA methylation measures to improve normality and stabilize the variance. We further performed permutation tests on the observed top two loci to ensure the robustness of our results, and conducted exploratory mediation analysis to evaluate whether DNA methylation mediates the effect of $PM_{2.5}$ on mitochondrial DNA content (SI Methods). Analyses were performed using SAS 9.4 (SAS Institute) and R statistical computing software (R Foundation for Statistical Computing).

Data Availability. Data are available on request due to privacy or other restrictions.

ACKNOWLEDGMENTS. This study was supported by NIH Grants R21ES021895, R01ES015172, R01ES021733, R01ES020836, R01ES021357, P30ES009089, and P30ES000002; US Environmental Protection Agency funding (Grant RD-83479801); Environment Canada; AllerGen Networks of Centres of Excellence; and National Natural Science Foundation of China Grant 91643202.

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To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Koutrakis, Petros
Sent: Wed 1/11/2017 9:32:35 PM
Subject: Re: Your presentation at the 12/7 Indoor Air and Climate Change meeting

Vito I am ok with the version you have

Regards Petros

Sent from my iPhone

On Jan 12, 2017, at 1:04 AM, Ilacqua, Vito <Ilacqua.Vito@epa.gov> wrote:

Dear presenters,

Thank you again for your work and your time in making the meeting successful. The feedback that we received from our webinar audience in particular was very positive, and demonstrated interest in further considering your presentations. We are preparing to post them on the meeting web site (a bit behind schedule).

If the version you sent me before the meeting is fine to be posted, you don't need to do anything further. If you have any concerns with posting some of the slides (e.g. results too premature, future publication,…), please send me a redacted version by Tuesday 1/17. If you need more time, please let me know.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Petros Koutrakis
Sent: Wed 12/7/2016 11:04:34 PM
Subject: Dinner

Vito Jeremy and I will be a little late because he has to deal with something back home.

Sent from my iPhone

To: Sarnat, Jeremy[jsarnat@emory.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Tue 12/6/2016 3:43:38 PM
Subject: RE: Logistical information for next week's meeting in DC

Alice here are the slides fr my presentation read them to edit it should not take much time

From: Sarnat, Jeremy [mailto:jsarnat@emory.edu]
Sent: Tuesday, December 6, 2016 10:26 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: RE: Logistical information for next week's meeting in DC

Petros - I will send to you shortly.

Jeremy

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Tuesday, December 06, 2016 10:25 AM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>; Sarnat, Jeremy <jsarnat@emory.edu>
Subject: RE: Logistical information for next week's meeting in DC

Hi Vito I will be done within an hour and I will send it to you.

Jeremy will have a separate presentation. But he could send it to me to put them in one file

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Tuesday, December 6, 2016 9:06 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: FW: Logistical information for next week's meeting in DC

Good morning Petros,

Due to the logistics of this meeting, not at our site, we need to compile a master slide deck in advance. Please send me your presentation (and Jeremy's if separate) as soon as possible.

Looking forward to seeing you tomorrow.

Thank you

Vito

From: Ilacqua, Vito
Sent: Thursday, December 01, 2016 3:57 PM
To: 'dsailor@asu.edu' <dsailor@asu.edu>; 'Howard Kipen' <kipen@eohsi.rutgers.edu>; 'Koutrakis, Petros' <petros@hsph.harvard.edu>; 'jsarnat@emory.edu' <jsarnat@emory.edu>; 'Smythe, Alice' <asmythe@hsph.harvard.edu>; 'gcm@mst.edu' <gcm@mst.edu>; 'brent@iit.edu' <brent@iit.edu>; Breen, Michael <Breen.Michael@epa.gov>; 'Lamb, Brian K' <blamb@wsu.edu>; 'tjobson@wsu.edu' <tjobson@wsu.edu>; 'Tonn, Bruce E' <btonn@utk.edu>; 'shelly.miller@colorado.edu' <shelly.miller@colorado.edu>; G Brown <gzbrown@uoregon.edu>; 'ckuejio@gmail.com' <ckuejio@gmail.com>
Subject: Logistical information for next week's meeting in DC

Dear participants,

Here are the promised logistical details for you. I have also attached the final (hopefully!) version of the agenda. You may notice I had to re-arrange the timing of several presentations compared to earlier drafts. Feel free to share webinar registration information and agenda with those you think may be interested.

Just a few details to help you plan the meeting days:

- The meeting site is about 30 min from the hotel, by public transportation or walking (slightly faster). Please plan accordingly.
- The closest Metro stop to the meeting site is Shaw-Howard (Yellow-Green line). The best Metro stop from the hotel is Farragut North (Red line). There are of course alternative transportation options.
- For any unforeseen events on the meeting days, my cell phone is 732 343 2614
- Lunch is on your own, but there are nearby eateries
- We plan on having dinner together after the first day. Please confirm if you are interested.

If you have not done so yet, please send your slides to me by COB Monday.

Should you have any other questions, do call or email me.

Thank you very much

Vito

Science to Achieve Results (STAR): Indoor Air & Climate Change Progress Review Meeting

Location: Interdisciplinary Research Building at Howard University

Address: 2201 Georgia Ave NW, Washington, DC 20059 (Multi-purpose Room – 106 A)

Website: http://www.howard.edu/expandingthecapstone/researchbldg.htm

Wednesday, December 7, 9-4:30PM EST

Thursday, December 8, 9-12:30PM EST

Click here to register for the webinar (Registration is FREE):

Day One: https://attendee.gotowebinar.com/register/3278455980999258113

Day Two: https://attendee.gotowebinar.com/register/1884063031235151617

Vito A. Ilacqua, Ph.D.

Physical Scientist

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Washington, DC 20004

To: Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]; Jeremy Sarnat[jsarnat@sph.emory.edu]
From: Koutrakis, Petros
Sent: Tue 12/6/2016 3:24:45 PM
Subject: RE: Logistical information for next week's meeting in DC

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From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
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Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
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<brent@iit.edu>; Breen, Michael <Breen.Michael@epa.gov>; 'Lamb, Brian K' <blamb@wsu.edu>; 'tjobson@wsu.edu' <tjobson@wsu.edu>; 'Tonn, Bruce E' <btonn@utk.edu>; 'shelly.miller@colorado.edu' <shelly.miller@colorado.edu>; G Brown <gzbrown@uoregon.edu>; 'ckuejio@gmail.com' <ckuejio@gmail.com>
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To: Dominici, Francesca[fdominic@hsph.harvard.edu]; Zeft, Andrew[ZEFTA@ccf.org]; Kazuhiko Ito[kito1@health.nyc.gov]; Peel,Jennifer[Jennifer.Peel@ColoState.EDU]; Zanobetti, Antonella[azanobet@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Wed 6/21/2017 1:22:38 AM
Subject: Invitation to present at upcoming webinar about your STAR grant

Dear STAR grantees,

Although your projects on the EPA STAR RFA '[Exploring New Air Pollution Health Effects Links in Existing Datasets]' have ended for some time (for some more than for others), there is continuing interest in EPA and beyond for some of the results you produced and for the methodological approaches you developed. In particular, in a moment of declining research funds for dedicated cohort studies, there is even more interest in using data already collected for additional explorations of health effects.

To address these requests I would like to invite you to give a presentation of your results once again, through a webinar that we plan to organize sometime in September. We hope that since no travel is involved and you already prepared the presentations in the past, this may not be an undue additional burden on your schedule. Some of you actually have more recent results and publications from these grants since you presented in RTP, and you are encouraged of course to share them. If you could also share insight from your experience working with data that was not purposefully collected to answer the questions you addressed (advantages, downsides, the extent that expectations had to be revised, etc.), it would be very appreciated by our intended audience.

Please follow the link to the Doodle poll below, to indicate days and times more convenient to you. The proposed dates are not in conflict with ISEE. It is not expected that you be available for the entire duration of the webinar beyond your own presentation, though of course you are welcome to. We don't yet have a schedule, but each presentation could last from 30 to 45 min, based on the material you already developed. The webinar is intended to be public, including public health professionals from other federal and state agencies, and academia.

http://doodle.com/poll/begdkqf2ktwy5bgx

Thank you for considering sharing your contributions once again

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Mon 5/15/2017 2:03:29 PM
Subject: ACE center grant monitoring

Dear Petros,

I'll be taking advantage of all the work you are putting into the SAC meeting to do a site visit for this year. This is just for your information, nothing is needed from you at this point. If need be, I'll follow up with additional questions. You'll receive a report later in the summer.

Looking forward to the meeting tomorrow

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Mon 3/27/2017 6:42:23 PM
Subject: RE: Letter to the Editor on our PNAS article

Thank you for the heads up, Petros. Important paper, on a topic that should be getting more general attention these days.

I plan to be at HEI, unless budget or other surprises get in the way. Looking forward to seeing you there, too.

Vito

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, March 27, 2017 11:37 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Subject: FW: Letter to the Editor on our PNAS article

FYI, confidential

Are you going to HEI meeting, if yes I am looking forward seeing you there

From: Baccarelli, Andrea [mailto:ab4303@cumc.columbia.edu]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Diane Gold <redrg@channing.harvard.edu>; Jia Zhong <jiazhong@mail.harvard.edu>
Subject: Letter to the Editor on our PNAS article

Hi Petros,

We received a letter sent by Lucock et al to the PNAS editor that is critical of our article.

We prepared (I need to say that Diane did most of the work) a response that is attached here.

Due to the sensitivity of the issue discussed, we would appreciate your review of our response. I am attaching the PDFs of our published article as well as of the letter submitted by Lucock et al.

Andrea

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Fri 2/17/2017 1:24:34 PM
Subject: Next ACE Centers directors call

Good morning Petros,

We are considering whether it is necessary to have the call next week. The planning for the annual meeting seems the most time-sensitive business, but there was not much discussion about it on the last call. Do you have a preference, or specific issues to be decided by the group? If you do, perhaps we may do so through email even if we don't hold a meeting, but we defer to you on this.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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To: Lawrence, Joy[lawrence@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]; Vallarino, Jose[jvallari@hsph.harvard.edu]; Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Fri 2/3/2017 2:13:18 PM
Subject: FW: Comments on Harvard QMP (ACE Center)
QMP-Harvard EPA ACE Center.docx
Jose QMP comment responses.docx

Thank you, Joy.

The revisions were evaluated and are fine. Please submit a copy of the front page with signatures.

Thank you

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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From: Lawrence, Joy [mailto:lawrence@hsph.harvard.edu]

Sent: Monday, December 19, 2016 3:50 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>; Vallarino, Jose <jvallari@hsph.harvard.edu>
Subject: RE: Comments on Harvard QMP (ACE Center)

Hi Vito,

Our revised QMP is attached, along with Jose's summary of our responses to the comments on the QMP and what changes in have been made. Please let us know if anything additional is needed.

Best,

Joy

Title and Signature Page

Regional Air Pollution Mixtures: The Past and Future Impacts of Emission Controls and Climate Change on Air Quality and Health
Quality Management Plan

RD- 83587201

Date: December 15, 2016

Approved By:

____________________________Date_______
Petros Koutrakis
Harvard School of Public Health (HSPH)
Center Director
PI Project 1

____________________________Date_______
Brent Coull
Harvard School of Public Health (HSPH)
Center Co- Director
PI – Project 2

____________________________Date_______
Joel Schwartz
Harvard School of Public Health (HSPH)
PI- Project 3

____________________________Date_______
Francesca Dominici
Harvard School of Public Health (HSPH)
PI- Project 4

____________________________D
ate_______
Noelle E. Selin
Massachusetts Institute of
Technology (MIT)
PI Project 5

____________________________D
ate_______
Christine Choirat
Harvard School of Public Health
(HSPH)
Data Manager

____________________________D
ate_______
Choong-Min Kang
Harvard School of Public Health
(HSPH)
Air Pollution Core Director

____________________________D
ate_______
Jose Vallarino
Harvard School of Public Health
(HSPH)
Quality Assurance Manager

National Center for Environmental Research
U.S. Environmental Protection Agency

________________________ Date_______
Lisa Doucet
Office of Research and Development

Summary

The researchers participating in this Center are strongly committed to good science and aggressive quality management (QM) practices. Our commitment is documented by developing integrated QM practices for our monitoring and measurement activities, statistical analyses and mathematical modeling within our purview. These QM practices are specifically designed to generate and process data of known and appropriate quality. This Quality Management Plan (QMP) summarizes the Quality Assurance (QA) structure of the Center, and identifies the quality control responsibilities of all researchers operating under the Center. The QM Program described by this QMP will be administered by the QA Manager, who will report directly to the Center Director. The Principal Investigators (PI) of the five Research Projects and the Cores under this Center will be responsible for administering the QA efforts necessary to obtain data of sufficient quality to meet the defined data quality objectives. We will organize an internal audit system to document these efforts. The frequency and specific points of evaluation of these audits will be designed during the development of individual Quality Assurance Project Plans (QAPP) for data collection or Research Plans (RP) for epidemiological and other modeling (projects using secondary data and/or models) for each study. These QAPPs and RPs are prepared by the individuals who are directly involved with the research. We will use the specific plan preparation as a planning tool, so that the research team fully understands all research tasks including external data, equipment, personnel and data security needs, sample and data storage and handling requirements, data streams and quality control (QC) checks. QAPPs are formal documents that will be in place prior to data collection. For our modeling efforts, the research tasks are planned and organized using Research Plans (RP). These are less formal working documents that are developed during investigator project meetings and continue evolving during the analysis and meeting process.

1. Organization and Management

1.1.1 Organizational Structure

Figure 1 shows the Center's Organizational Structure. The PI of each Project and Core is responsible for overseeing the planning, execution and reporting of the work of their Project or Core. The QA manager, reporting directly to the Center PI, is tasked with conducting independent review of the quality systems in place for each project and cores and assuring that these systems comply with the Center's Quality Management Plan (QMP).

1.1.2 Responsibilities

The Center Director will have ultimate responsibility over all Center QA activities. The Center QA Manager, Mr. Jose Vallarino, will be responsible for implementing the QM program. Mr. Vallarino is a Project Manager in the research group of Dr. Joseph Allen (who is not a PI or Co-PI of the proposed Center) at Harvard School of Public Health. Mr. Vallarino's extensive QA management experience is detailed in the *Administrative Unit*. The QA Manager's main tasks are: 1) prepare and implement the Center's QA Program; 2) provide technical assistance and guidance to Center researchers in the preparation QAPPs, RPs and Standard Operating Protocols (SOPs); 3) review and evaluate project plans and SOPs, including audit programs; 4) coordinate and document response actions; 5) manage human subjects protection program; and 6) provide technical assistance to Center researchers in preparation of human subjects applications for exemption determinations and non-human subjects research determinations. The Center's Administrator will be responsible for archiving all quality-related and human subjects' related documents and forwarding relevant documents to the EPA. To facilitate compliance with the various data use agreements, each Project/Core data manager will prepare their own Data Management Plan (DMP) specific to each data use agreement. The QA Manager will be responsible for compiling the individual project DMPs into an overall Center DMP.

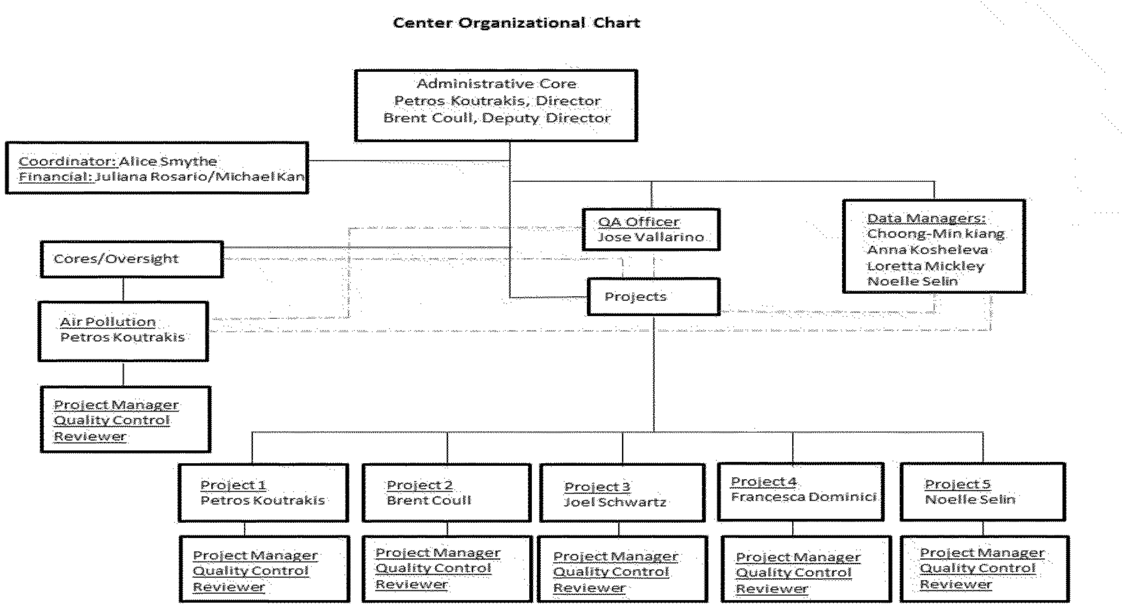

Figure 1 Center's Organizational Structure

Center Key Personnel:

Name; Institution; Role; Background; Contribution

*Petros Koutrakis, Ph.D.; HSPH; PI Project 1; Env. Chemistry; Exposure assessment

**Brent Coull, Ph.D.; HSPH; PI Project 2; Biostatistics; Spatiotemporal models

Joel Schwartz, Ph.D.; HSPH; PI Project 3; Env. Epidemiology; Air pollution health effects

Francesca Dominici, Ph.D.; HSPH; PI Project 4; Biostatistics; Accountability assessment

Noelle E. Selin, Ph.D.; MIT; PI Project 5; Atm. Chemistry; Integrated assessment modeling

Loretta Mickley, Ph.D.; HSEAS; Co-PI, Project 1; Atm. Chem & Climate; Atm. chemistry modelling

Daniel Jacob, Ph.D.; HSEAS; Co-PI, Project 1; Atm. Chemistry; Atm. chemistry modelling

Antonella Zanobetti, Ph.D.; HSPH; Co-PI, Project 3; Biostatistics; Health effects analysis

Corwin Zigler, Ph.D.; HSPH; Co-PI, Project 4; Biostatistics; Policy assessment

Steven Barrett, Ph.D.; MIT; Co-PI, Project 5; Atm. Chemistry; Adjoint transport modelling

Susan Solomon, Ph.D.; MIT; Co-PI, Project 5; Atm. Chemistry; Climate and chemistry

John Reilly, Ph.D.; MIT; Co-PI, Project 5; Economics; Economic modelling

Kenneth Demerjian, Ph.D.; Retired Consultant; Physical Chemistry; Source emissions

Joy Lawrence, Sc.D.; HSPH; Co-Investigator; Env. Health; Exposure assessment

Jack M. Wolfson, Ph.D.; HSPH; Co-Investigator; Chemistry; Air quality measurements

Christine Choirat, Ph.D.; HSPH; Co-Investigator; Computer Science; Data management

Choong-Min Kang, Ph.D.; HSPH; Co-Investigator; Chemistry; Air quality monitoring

Jose Vallarino, HSPH, Quality Assurance Officer

Carey Friedman Ph.D.; MIT; Key Personnel; Env. Chemistry; Toxic air pollutants

Erwan Monier Ph.D.; MIT; Key Personnel; Climate Science; Climate change impacts

*Center Director; **Center Deputy Director.

Research Project QM Responsibilities include:

- All research projects shall have a designated PI, Project Manager and QC reviewer. The PI is responsible for the overall project. The Project Manager is responsible for the day-to-day operation of the project, and the quality control reviewer is responsible to perform the periodic audits as identified in the RP or QAPP.
- All environmental and/or health response data generated shall be of known and acceptable quality. The data quality information developed with all (environmental and health response) data shall be documented and available. The flow of data and the validation steps for each data stream shall be identified in the RP, DMP or QAPP.
- Training requirements and a plan for documenting required training of all personnel collecting or analyzing data on the project shall be included in the project plan.
- The intended use(s) of the data will be defined before the data collection effort begins, so that appropriate QM measures may be applied to ensure a level of data quality required by the study objectives. The determination of this level of data quality will also consider the prospective data needs of secondary users since air pollution data from several studies are often aggregated into meta-analyses. Data Quality Objectives (DQOs) shall be established to ensure the utility of data for its intended use and as guidance for preparation of project plans. The Research Project Principal Investigator shall be responsible for determining the appropriate QM practices, using the DQO process for each RP or QAPP. The intended data uses, level of quality, specific QM activities, and data acceptance criteria needed to meet the data quality needs of these uses shall be described in each RP or QAPP.
- Principal investigators from other institutions, as well as Center researchers, shall be required to follow the requirements of this QMP.

2. Quality System

2.1 Bi-weekly PI meetings and project key personnel meetings

The Center will have bi-weekly meetings of the PIs and research staff. The purpose of these meeting is to review progress on the research projects, including discussion of any issues that may have an impact on data quality. Although these meetings have a written agenda, they will also include an open agenda session where there is time allotted for researchers to bring up any items they would like discussed at the meeting. Separate from these bi-weekly Center meetings each Project PI shall determine the number and frequency of Project meetings required of key Project personnel for each of the project's tasks. These Project Key personnel meetings are where the PI conducts direct oversight for all research activities for the Project. Project PIs will use these meetings to (1) assure that the mathematical bases of models reflect the process they represent; (2) document that the numerical [computer code] is accurately estimating the mathematical model, and;

(3) determine how the model results will be validated. In addition, the PI will determine the requirements for code verification for each research effort. These tasks will be planned and delegated at these project key personnel meetings.

2.2 Periodic Audits

The Center's QM program will consist of periodic program audits in combination with a series of pre-defined systems audits covering the various research aspects of each specific project. The QA officer will conduct an annual independent audit of each Research Project and the Air Pollution Core. Annual performance audits of laboratories will be conducted during the laboratory analysis efforts.

2.2.1 QM Program Audits

QM Program audits of the overall project will be performed by the QA Officer. The Center Director will be notified of any issues affecting data quality when they are identified. QM systems audits of study exposure and health assessments will be performed by individual study team members, designated in the QAPP, and not directly involved in the specific data collection effort, but who are familiar with the analysis being audited. An over-arching QA effort is proposed. The effort incorporates several important qualities: (1) performance of QA efforts by an investigator removed from immediate field operational responsibilities in the project, but experienced in the critical facets of both the exposure and health assessment fields; (2) a discrete but interlocking series of QA tasks performed to establish overall project veracity, and; (3) a timely and focused QA scope of work. In this manner, there will be a discrete separation of functional project responsibilities within the overall project. Table 1(section 2.2.2) lists the frequency of the required program and systems audits. Table 2 (section 2.9) lists the quality documents required under the Center. For the initial scheduled review, an audit report checklist outlining the scope of the audit, items to be evaluated, criteria used for the evaluation, and required corrective response actions to be implemented if criteria are not met, will be completed. The audit report forms will be developed during the SOP and RP and QAPP review approval process, and will be included in the relevant RPs, QAPPs or SOPs. The completed audit report will be made part of the year 1 Quality Management Report. In years 2 through 5, a subset of publications produced by the research effort will be audited. The scope of this audit is to assure that the supporting material for the publication, data, program code, review notes and responses to reviewers is archived according to the Center's archiving requirements and that and results can be reproduced upon request.. Select figures and data in the text will be selected at random to confirm that they can be regenerated upon request.

2.2.2 Data Quality Audits

All environmental measurements will have a monthly data quality audit to assure that pre-set criteria for completeness, LOD, precision, and maximum sample holding time are being met. Should the pre-established quality criteria not be met in any month, a predefined series of response actions will be implemented to identify and correct the cause. These data quality audits will be automated in the database, assuring that any deviations of the proposed data quality will be quickly identified and corrected, and thereby assuring consistent data quality throughout the entire data collection effort. These automated data quality reports will be reviewed monthly during the data collection and analysis period. The data quality report form will be included in the QMP and the process will be evaluated as part of the annual Quality Management efforts. At a minimum, our target is to collect 10 percent blank and 10 percent duplicate samples for all parameters of integrated samples. However, we may increase the number of blanks and duplicates to assure sufficient numbers of these samples are available monthly for the data quality audits.

Table 1: Program and System Audits

Program Audits	**Frequency**	**Exposure Assessment Systems Audits**	**Frequency**
Quality Mgmt. Program	Initial Approval and Yearly	Review of QAPPs and SOPs	Initial Approval and Yearly
Data Mgmt. Program (overall & by project)	Initial Approval and Yearly	HSPH Environmental Laboratories	Yearly
Human Subjects Protection Program (IRB & HIPPA) (overall & by project)	Initial Approval and Yearly	Field Data Sets and Code Books	As Finalized
Training Program for Field & Lab Technicians	Initial Approval and Yearly	Laboratory and Field Data Management	Annually
Data Sharing	Initial	Outdoor	Annually

Agreement Mgmt. Program	Approval and Yearly	Monitoring Stations	

2.3 Data Management

The Center Data Management Plan (DMP) will establish an overall plan for the data management requirements for each project. The purpose of the DMP shall be to provide the necessary management and control of the data items. The DMP will cover the following topics: file structure; file and variable naming conventions; data integrity; code book requirements; variable construction documentation; and integration of the various data sources. All data collected for the study will be recorded directly, accurately, promptly, and legibly. The individual(s) responsible for data integrity, computerized and hard copy, will be identified in the DMP. Procedures used to verify and promote the quality and integrity of the data will be outlined in writing. A historical file of these procedures shall be maintained, including all revisions and the dates of such revisions. Any changes in data entries shall be documented. The DMP will include data storage and manipulation guidelines to assure a consistent data set. For data covered by data sharing agreements, a written plan will be prepared to control data access and assure compliance with contractual obligations. The requirements for archiving or destroying data specified in these agreements will supersede the requirements of the DMP. All current and past authorized users of each of the data sets will be kept in a log.

2.4 Research Project QM Responsibilities

All Center Research Projects and Cores shall have a designated PI, Project Manager and QC Reviewer. The PI is responsible for the overall project. The Project Manager is responsible for the Project's day-to-day operation, and the QC Reviewer is responsible to perform the periodic audits as identified in the Project's QAPP or RP.

2.4.1 Data Generation QM Requirements

Each Research effort that generates environmental data (i.e., Air Pollution Core) shall develop and implement a QAPP addressing the major elements contained in EPA guidance document EPA QA/G5 "EPA Guidance for Quality Assurance Project Plans", and shall ensure that adequate resources (both monetary and staff) are provided to support the QM, QA, QC objectives of the QAPP. The QAPP shall specify the procedures needed to assure the generation of quality data. All laboratories analyzing research samples must have a written QA Program or Laboratory SOPs addressing the major elements of: EPA-910/9-92-032 "Guidance on the Preparation of Laboratory Quality Assurance Plans" and EPA QA/G6 "Guidance for the Preparation of Standard Operating Procedures for Quality Related Documents". All data collected and or analyzed by the Air Pollution Core, including the Harvard Supersite and all new analyses on previously collected filter samples, will be performed following existing SOPs. Thus, all environmental data generated shall be of known and acceptable quality. The data quality information developed with all environmental data shall be documented and available. The flow of data and the validation steps for each data stream shall be identified in the QAPP or DMP. The following data will be collected at the Harvard Supersite under the Air Pollution Core: Continuous and integrated measurements of ambient PM2.5, PM10, black carbon (BC), elemental carbon (EC), and organic carbon (OC). Particle number (PN) concentration will be measured continuously. Sulfate and trace elemental concentrations will be determined for PM2.5 and PM10 from integrated samples. The Environmental Chemistry Laboratory (ECL) at HSPH has SOPs documented for each integrated method mentioned here. The Air Pollution Core has SOPs documented for each continuous method identified above. These QM documents will be updated as required by software updates or new technology. These updates will be reviewed during the annual audits.

2.4.2 Research QM Requirements (Secondary Data and Modeling)

QA oversight for each epidemiologic, exposure, or other modeling project will be conducted through academic peer working groups. These informal working groups have a collaborative and non-hierarchical organizational structure which allows for the exchange of ideas necessary to develop appropriate models and refine the RP. During these informal working group meetings the type of data, sample size determinations and the procedures for verifying and compiling data inputs from various sources will be finalized and incorporated into the research plan.

The intended use(s) of the data to be collected, acquired or modelled will be defined before the data acquisition effort begins, so that appropriate QM measures may be applied to ensure the required level of data quality. The Project PI shall be responsible for determining the appropriate QM practices, using the Data Quality Objective process for each QAPP or RP. Variables or data created from model outputs will be included in the meta-data or codebook information on the model or models used to create the data. The information will include the date of the model; the version number of the model, the date the model was run to generate the data, and the sources of and location of all the inputs used by the model or models. The intended data uses, level of quality, specific QM activities, and data acceptance criteria needed to meet the data quality needs of these uses shall be described in each QAPP or RP. The RP or QAPP shall be reviewed at least annually by the Center QA Manager and updated as required. All outputs from models developed shall be evaluated as set forth in the project Research Plan. These validations may include validation with observations, validation with simulated data, validation with other models, Monte Carlo validations with random subset of the data.

2.4.3 Publication QM Requirements

The Center review process for publications and reports requires the lead author on the paper or report to be responsible for the overall product. The co-researchers provide critical reviews of the work through an iterative process, initially through reviews of preliminary analyses. Once it is determined that the analysis warrants publication, the lead researcher prepares a draft of the paper. The paper is reviewed by the co-investigators until all are satisfied. The number of iterations varies but on average there are three iterations. All manuscripts must be reviewed and approved by the Center Directors. Once internal reviewers have been satisfied, the paper is finalized and then presented to a journal, upon which an external peer review of the paper is undertaken. Prior to sending the paper to a journal the lead researcher is responsible for filling out a manuscript data form and filing it with the Data Manager. When the external reviewers are satisfied, the paper is published and deemed complete.

2.4.4 External Data and Models

All external data shall be evaluated for completeness, outliers, missing values, logic tests (i.e. PM_{10}>$PM_{2.5}$) and compliance with documentation provided or available with the datasets. Anomalies found shall be reconciled with the data provider. Users of external data will be required to review all documentation (e.g., meta-data, assessment reports, data validation reports, data quality reports and data dictionaries or code books provided with or available for the data. Users of external data will incorporate the findings of the data quality assessments into the Project's data dictionary. All researchers using or incorporating external models or data (MODIS MAIAC, OMI, CMAS, GEOS-CHEM, CMS etc.) shall determine the relevant training required to understand intricacies of the model or data and enroll as provided in online training modules offered by the model or data sources. The researchers will sign up for mailings, and notification of changes to the model or data set and review these documents offered by the data provider. The researchers shall visit the model or data providers' website quarterly for any updates to the models or data. GIS meta-data will follow Federal Geographic Data Committee (FGDC) endorsed standards and FGDC-endorsed external standards.

2.4.5 Quality documents

The five Research Projects will have the following Quality Documents as part of the research effort: Projects 1, 2, 3, 4 and 5: Research Plans; Projects 1, 2, 3, and 4: project specific Data Management Plans. All projects will have data codebooks or dictionaries, data user logs, data or model validation plans. All projects will follow the Center's manuscript archiving SOP and data use agreement SOPs. In addition, the Air Pollution Core will also have sampling, sample handling and laboratory SOPs for sample collection and analysis efforts.

2.4.6 Sample Size and Validation requirements

Sample size, validation requirements and data needs for each research task are established consistently with the guidelines described in section 2.4.2 above, covering QM requirements of secondary data and modeling. The PIs and Project Managers, as part of the Research Plan development process, will define the specific validation needs for each research task.

2.4.7 Planning

It is the Center's policy that systematic planning shall occur for all research projects. Depending on the scope of research, planning documents (including research plans or QAPPs) appropriate to the scope are developed. The Center QAO and PIs participate in Center planning meetings as directed by Center management.

Effective quality planning requires clear identification of project goals and intended use of data. The PI for the project, in consultation with other project participants and the Center QAO, determines the appropriate Research Plan or QAPP requirements to be used to ensure the project's success.

It is the PI's responsibility to identify and involve any and all appropriate personnel, stakeholders, scientific experts, *etc.* in the planning of the project. Once the planning is complete, project documentation should include (at a minimum) a complete description of the following:

- The project's goals, objectives, questions, and issues to be addressed;
- The project's schedule, resources (including budget), milestones, and any applicable requirements (*e.g.*, regulatory requirements, contractual requirements);
- The type of data needed and how the data will be used to support the project's objectives;
- The quantity of data needed and the specification of performance criteria for measuring data quality;
- How, when, and where the data will be obtained (including existing data) and identification of any constraints on data collection;
- Specifications of needed QA/QC activities to assess the quality performance criteria (*e.g.*, QC samples for both the field and laboratory, audits, technical assessments, performance evaluations, *etc.*);
- How the acquired data will be analyzed (either in the field or the laboratory), evaluated (*i.e.*, QA review, validation, verification), and assessed against the quality performance criteria and for its intended use.
- Training requirements and a plan for documenting required training of all personnel collecting or analyzing data on the Project shall be included in the project plan.

- As stated in our Human Subjects Research Statement, exemption or non-human research determinations have been be obtained for each Research Project that involves data originating from human subjects. All Investigators will maintain their individual IRB training requirements current throughout the project for all research using data originating from human subjects whether the specific project has been determined by the IRB to be human subjects research or not.

Once all project planning is complete and documented, it is the PI's responsibility to submit the QAPP to the Center QAO. The QAO performs a review against QAPP requirements and issues either an approval or a non-approval. In the case of non-approval, detailed review comments shall be provided to the PI. Resolution of all findings shall be accomplished and documented before any research is started.

2.4.8 Database Development Projects 1, 2 and 4

Aims 1 and 2 of Research Projects 1 and 2, and Aim 1 of Project 4 are to compile data from internal and external sources as well as data from model inputs into a dataset to be used in the project and other projects of the center. This type of effort requires a considerable effort in Data Management which will use the efforts of the four Center Data Managers; each one will be tasked with a specific component of the effort. Compilation of the dataset will be the responsibility of the Project Data Manager. The individual Project Data Manager will be responsible for assuring that the data is identified and catalogued in a standardized manner, and will review data assessments, documentation of model-derived new variables, meta-data and data dictionaries, and compile them into a final data set and codebook that is consistent with the Project's Data Management Plan and Center QMP.

2.4.9 Implementation of Work Processes and Project Work Flow

All project PIs are responsible for meeting scientific expectations and milestones within their projects. PIs must also ensure that work performed by their immediate staff is performed in a timely manner in accordance with approved Research Plans or QAPPS and associated SOPs.

In addition to weekly project team meetings, the Center Director, project PIs, Key research personnel and the QAO meet biweekly as stated in section 2.1 to communicate project status, milestones, staffing changes, and research objectives, etc. Plans for audits and any other quality issues are also discussed.

Individual Project QA work flows are discussed below:

Project 1

Dr Petros Koutrakis will have the overall responsibility for overseeing the analytical framework of Project 1. He will be supported by Dr Brent Coull and Dr Joel Schwartz with statistical analyses, and Dr Daniel Jacob and/or Dr Loretta Mickley with atmospheric analyses. Dr Mickley will have primary responsibility for Objective 4 in this project, forecasting future weather and air quality changes for 2015-2040. Project 1 analysis conducted by doctoral students and post-doctoral fellows (e.g., Longxiang Li, Annelise Mesler, others TBD) will be done under the direction and supervision of one or more of the PIs of Project 1, monitored and documented through regular meetings and communications (e.g., email, skype, etc.).

Research protocols will be documented as follows:

- Statistical analyses protocols will be documented through manuscript writing and approved by Dr Koutrakis, and/or Dr Coull, and/or Dr Schwartz;
- Atmospheric modeling protocols will be documented and approved by Dr Koutrakis and/or Dr Jacob, and forecast modeling protocols documented and approved by Dr Mickley, to be updated and distributed with published analyses.
- Data protocols, including raw data sets, data linkage, and data set construction, will be approved by Dr Choong-Min Kang) and described in documentation distributed with manuscripts and software programs.
- Protocols will be updated as progress is made. Current versions will be distributed with programs and manuscripts.

Project 2

Dr Brent Coull will have the overall responsibility of overseeing the analytical framework of Project 2. Dr Coull will oversee the research activities of a Post Doc Joseph Antonelli and doctoral students Glen McGee and Zhe Liu. The oversight is through weekly group meetings in which the staff presents a summary of progress and results to the group. These summaries are archived in the study shared drive. Dr Brent Coull also holds informal meetings with the researchers. Periodically the research is presented at the bi-weekly center meeting for additional oversight. Once the research has gone through the center internal peer review process, the publication is then sent to a journal for external peer review.

Project 3

Dr. Joel Schwartz is responsible for overseeing the analytical framework of Project 3. In research meetings with his post-docs and students methods of analysis are developed. The post docs report of the results of the evaluation of the analytical methods during the meetings. For those methods that seem promising preliminary datasets are identified to further test and develop the method. If these reviews suggest a suitable method of analysis the analysis is tested on larger datasets. The results are presented at the biweekly Center meetings. Once the research has gone through the center internal peer review process, the publication is then sent to a journal for external peer review.

Project 4

Overall planning of the analysis framework will be overseen by Dr. Zigler and Dr. Dominici. Documentation of research protocols will fall into three categories. Statistical analyses protocols will be documented through manuscript writing and approved by Dr. Zigler and/or Dr. Dominici. Atmospheric modeling protocols will be documented and approved by Dr. Mickley, to be updated and distributed with published analyses. All data protocols, including raw data sets, data linkage, and analysis data set construction, will be approved by Dr. Choirat and described in documentation distributed with manuscripts and software programs. In all cases, updates will be made to these protocols as progress is made, with the current version distributed with programs and manuscripts.

Project 5

Professor Noelle Eckley Selin is the PI for project 5. She approves all design and statistical approach changes to Project Five. Co-I Dr. John Reilly is responsible for economic analysis conducted under this project. Co-I Prof. Steven Barrett is responsible for model quantitative techniques. Co-I Prof. Susan Solomon is responsible for atmospheric chemistry and climate aspects of the project. Dr. Erwan Monier is responsible for running the IGSM-CAM model and maintaining data archives and documentation of meteorological field output. Graduate Student Tao Feng conducts model runs and statistical analysis and is supervised by Profs. Selin and Solomon. Postdoctoral associate Dan Rothenberg (beginning 12/1) conducts model runs and statistical analysis and reports to Professors Selin and Solomon. Substantive changes to the project are discussed among the PI and co-Is and documented by email. Data archiving is supervised by Prof. Selin.

Air Pollution Core

Dr Petros Koutrakis is the PI of the Air Pollution Core. Dr. Choong-Min Kang will have primary responsibility for direct oversight of the Air Pollution Core, and will report to Dr. Koutrakis. Dr Kang will manage the data obtained from EPA monitoring sites, metrological stations, chemical analyses, and the supersite for use by the center. Longxiang Li, a research assistant, will change the $PM_{2.5}$ and PM_{10} filters at the site on a weekly basis. Irene Cho, a research assistant will do the X-ray fluorescence (XRF) and Organic and elemental carbon (OCEC) analyses for upcoming filter samples for projects. Dr. Kang will supervise them. All data collection and data processing are conducted following protocols and Standard Operating Procedures as detailed in the ACE Center Quality Management Plan. All data processing will be done by Dr. Kang and uploaded on a secured shared drive that is able to be accessed by other participating scientists.

2.4.10 QAPP/SOP Implementation

In some instances, procedures for sampling, analysis, or other quality activity (*e.g.*, standards preparation) are routine and are used for more than one project. Oftentimes, it is necessary that more than one person perform a procedure. In these cases, an SOP should be written. SOPs are also recommended for special or critical operations. SOPs can make the development of QAPPs more efficient, since they can be attached or referenced. The need for the development of an SOP is determined by the Center PI or QAO. SOPs must be reviewed and approved by the QAO.

It is the responsibility of the project PI to ensure that the required procedures specified during the planning process for a specific project are implemented during data collection activities. This is done by personally observing the procedures being performed or by requesting that the Center QAO perform an audit of the project activities outlined in a QAPP and/or SOP. In either case, deviations from project requirements must be documented, along with the corrective action performed. Corrective action must be performed as soon as possible to minimize any effect on data quality. If data quality is affected by any deviations, this must be discussed in any project report/paper.

2.4.11 QAPP/SOP Revisions

During the course of a project, it may be necessary to revise QAPPs and/or SOPs. The primary reasons for these updates are new technology or software updates. Revisions are required whenever a significant change in the plan or procedure occurs. Over time, it may also be necessary to revise QAPPs and/or SOPs to ensure they are still applicable for the work being performed. QAPPs and project-related SOPs need to be reviewed on a yearly basis for long term projects. Revisions (as necessary) in the form of an addendum or fully revised document must be made as soon as a significant change is identified. Significant revisions to a QAPP/SOP must be reviewed and approved by the QAO. It must then be verified that the revised procedures are being implemented properly. All previous document versions must be archived.

2.5 Center Communications

Center PIs along with Project key personnel (as required), will attend semi-monthly Center meetings. These meetings are established to plan and/or discuss progress on each research project, evaluate how any recent publications or findings affect the proposed research, and collaborate on redesigning or expansion of research activities to make best use of these findings. All issues pertaining to Data Quality (DQ) and associated response actions shall be brought up at these meetings, so that the impact on the DQ objectives for the study, Projects, and Center can be fully assessed. Communications with the EPA, including the Annual Quality Assurance Report Summary, shall be done through the Administrative Core.

2.6 Scientific Advisory Committee

A multi-disciplinary Science Advisory Committee (SAC) of nine distinguished scientists (six non-governmental and three (nonparticipant observers) from EPA or other government agencies) will be established to provide input into both on-going and future research directions. The Committee will meet annually for two days at our Center to review formally the Center's activities. The first meeting day will be devoted to the traditional presentation of study designs and results, during which the PI of each Project and Core will present his/her team's progress and insights from the preceding year, and current research plans. This will be followed by a structured workshop on the second day to define research needs and priorities. This workshop will include both SAC members and the Center Investigators. Following each SAC meeting, the SAC Chair will be responsible for soliciting comments from the SAC members, and preparing a written report to the Center Director, with a copy to the EPA Project Manager. Within three months of receiving the written recommendations from the SAC, the Center Director will submit a formal letter to the EPA Project Manager and the SAC Chair, with a response to the SAC comments, and a plan for how the Center will implement recommendations.

2.7 External Collaborators QA

Project 5 will be carried out at the MIT Joint Program for the Science and Policy of Global Change, under the direction of PI Dr. Noelle Selin. As stated in the *Project 5 Research Project Plan Description*, this project will the follow the QA management practices and programs discussed in the Center's QA Management plan, specifically items 2.1 to 2.6 above. External collaborators for new research with Center data (obtained as detailed in the Center's *Data Plan*) will be required to comply with the Center QMP procedures.

2.8 Assessment, Response, and Improvement

Research using models requires continuous assessment and evaluation. And assessment of how new work reported in the literature can enhance the research efforts underway. These assessments will be done in the peer working groups described above in Section 2.4.2. The ACE Center will provide planned, continuous evaluation of research needs and priorities. To achieve this goal during our current CLARC and previous PM Centers, we implemented a rigorous, multi-phase research coordination and evaluation process. The process draws on experts from a wide range of disciplines at the HSPH and from outside agencies, universities, and other organizations. For the proposed ACE Center, we will recruit additional researchers from HSEAS and MIT. Specifically, experts from four internal and external groups will contribute to the research coordination and evaluation process and will determine the direction and coordination of air pollution research that is conducted at the Center. These groups include: 1) the External Science Advisory Committee; 2) the Consortium of EPA Centers; 3) the Working Group on Exposures, Climate Change and Health Effects; and 4) the Center Steering Committee. This mechanism will continue to enable our Center to provide the most focused and timely responses possible to current and evolving questions about health effects of ambient pollution.

2.9 Documents and Records

There will be secure archives for the orderly storage and expedient retrieval of all study related material. An index will be prepared to identify the archived contents, to identify their location, and to identify by name and location any materials that by their general nature are not retained in the study archive. Access to the archives shall be controlled and limited to authorized personnel only. Archiving procedures and requirements will be described in the Data Management Plan.

Table 2: QM Documents

Documents	Scope	Evaluation	Status
QMP	Entire Center	Annual	On Hand
Research Plans	Projects 1,2,3,4,5 and Air Pollution Core	Audit checklist including points of evaluation, criteria and response actions	On Hand, updated as the research develops
SOPs	Integrated laboratory analysis methods Operation of continuous instruments	Operation checklist and periodic audit forms	On hand but will be revised to address specific needs of each project upon award
Managemen t Plans	Center Data Management Plan Individual Project Data management plans	Audits of data streams (individual and Combined),	Existing - to be updated to reflect all data streams

Operating Manuals	Standard Operating Manual for which projects in which external data is used and no internal data is generated. Standard Operating Manual for Projects in which GIS products are produced that will be integrated into environmental exposure assessment, epidemiology or risk assessment models.	Multi-level peer review	Existing - to be revised to reflect specific needs of the project.

2.10 Non-Standard Method Development and Validation

For all non-standard environmental sample collection methods, a written comprehensive method development and validation plan will be prepared and implemented. The plan will specify the performance criteria and tests to be conducted for validation. The requirements will be rigorous and include laboratory and field testing. These studies often require the development of new methodological innovations or applications of new methods from the statistical literature. Techniques suggesting a better approach to answering research questions may become available only after the research project is started. Standard Operating Manuals are in place, defining the required review process to accommodate this iterative process yet assuring the required quality of the analysis.

2.11 Protection of Human Subjects

Institutional Review Board approval or exemption will be obtained by all institutions participating in the project. All investigators will maintain their individual IRB training requirements current throughout the project. Investigators will ensure that personal identifiers will be removed from any files that are accessible to non-study personnel. All personnel with access to data containing personal identifiers will sign a pledge to maintain the confidentiality of study subjects. They will maintain an ability to verify the origin and integrity of data sets from which personal identifiers will have been removed. If investigator compliance with Human Subjects Protection requirements will be verified by the QA officer, who will keep on file all required protocols, approvals, training certificates and correspondence with the IRB. The individual Human Subjects applications will be submitted concurrently to the institutional review boards and to the USEPA reviewer. All required humans subjects documentation was filed with the proposal of this center.

2.12 Computer Hardware and Software

The data manger will keep a log of individuals using the research software described above in section 2.4.4. The Data Manager will be responsible for notifying individuals on her log of software updates, patches and other communication from the software supplier or custodian. All users must confirm receiving these updates to the Data Manger. If the software is used solely on one project, this duty will be delegated to the project Data manager.

To: Lawrence, Joy[lawrence@hsph.harvard.edu]; Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Tue 1/31/2017 1:43:32 PM
Subject: RE: Reminder of report coming due for your STAR grant

Thank you, Joy. I have received the report.

Vito A. Ilacqua, Ph.D.

Physical Scientist

(202) 564 4512 | ilacqua.vito@epa.gov
National Center for Environmental Research | ORD | US Environmental Protection Agency
1200 Pennsylvania Avenue NW (8725R)

Washington, DC 20460

Office/Courier:
Ronald Reagan Building M315B

1300 Pennsylvania Avenue NW

Washington, DC 20004

From: Lawrence, Joy [mailto:lawrence@hsph.harvard.edu]
Sent: Monday, January 30, 2017 6:07 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: RE: Reminder of report coming due for your STAR grant

Hi Vito,

Attached please find the annual report for Y2 of our STAR Grant 835755, which is due February 1, 2017. Thank you again for the reminder—the date was already in my calendar from last year.

We're getting the ACE Center annual report together also, and expect to submit that soon. Certainly in advance of the 2/28/17 deadline.

Hope all is well there,

Joy

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Wednesday, January 11, 2017 10:15 AM
To: Koutrakis, Petros
Cc: Lawrence, Joy; Smythe, Alice
Subject: Reminder of report coming due for your STAR grant

Dear Petros,

I hope the New year is starting well for you. This is a reminder that the annual report for your STAR grant 835755 will be due on February 1st.

Guidance for the format of the report can be found under the Terms and Conditions applicable to your award, at https://www.nsf.gov/pubs/policydocs/rtc/agencyspecifics/epa_314.pdf - under Article 8, section A.

Thank you for your attention to this deadline.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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Washington, DC 20460

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1300 Pennsylvania Avenue NW

Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Tue 1/24/2017 9:18:58 PM
Subject: RE: Funding request for 2017

Yes

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Tuesday, January 24, 2017 4:18 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Coull, Brent <bcoull@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>; Francis, Bradford <bfrancis@hsph.harvard.edu>; Lawrence, Joy <lawrence@hsph.harvard.edu>
Subject: Re: Funding request for 2017

Thanks Vito
We will do

This will be for year three for ACE?

Correct?

Sent from my iPhone

On Jan 24, 2017, at 3:55 PM, Ilacqua, Vito <Ilacqua.Vito@epa.gov> wrote:

Good afternoon Petros,

I hope you had a successful trip. Notwithstanding what you may have read in the news, at the moment we are continuing at least the paperwork for next year's funding. Please do send me a request when possible.

Thank you

Vito

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Friday, December 30, 2016 1:47 PM
To: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Francis, Bradford <bfrancis@hsph.harvard.edu>; Lawrence, Joy <lawrence@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: RE: Funding request for 2017

Hi Vito and happy new year. I am about to leave for china and korea and I will be away the next two weeks. However, Brad, Alice and Joy will take care of this. I will check my emails thought my trip.

Regards Petros

From: Ilacqua, Vito [mailto:Ilacqua.Vito@epa.gov]
Sent: Friday, December 30, 2016 1:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: Funding request for 2017

Dear Petros,

When possible, please send me a request for another year of Center funding for 2017. This is the usual request on letterhead, indicating whether or not everything is proceeding satisfactorily, and whether these funds are needed for the project.

I will assume the previous budget still applies, but you can follow up with a revised one later, if appropriate.

Thank you and Happy 2017!

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]; Francis, Bradford[bfrancis@hsph.harvard.edu]; Lawrence, Joy[lawrence@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Tue 1/24/2017 8:55:10 PM
Subject: RE: Funding request for 2017

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Sent: Friday, December 30, 2016 1:47 PM
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Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
Subject: RE: Funding request for 2017

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Regards Petros

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Sent: Friday, December 30, 2016 1:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Smythe, Alice <asmythe@hsph.harvard.edu>

Subject: Funding request for 2017

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Thank you and Happy 2017!

Vito

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Washington, DC 20004

To: Howard Kipen[kipen@eohsi.rutgers.edu]; dsailor@asu.edu[dsailor@asu.edu]; Koutrakis, Petros[petros@hsph.harvard.edu]; jsarnat@emory.edu[jsarnat@emory.edu]; Kolb, Laura[Kolb.Laura@epa.gov]; Morrison, Glenn[gcm@mst.edu]; Dols, William Stuart (Fed)[william.dols@nist.gov]; Brent Stephens[brent@iit.edu]; Breen, Michael[Breen.Michael@epa.gov]; Lamb, Brian K[blamb@wsu.edu]; Crimmins, Allison[Crimmins.Allison@epa.gov]; Tonn, Bruce E[btonn@utk.edu]; Shelly Lynn Miller[shelly.miller@colorado.edu]; Jeffrey Kline[jkline@uoregon.edu]; ckuejio@gmail.com[ckuejio@gmail.com]
From: Ilacqua, Vito
Sent: Wed 1/11/2017 4:04:42 PM
Subject: Your presentation at the 12/7 Indoor Air and Climate Change meeting

Dear presenters,

Thank you again for your work and your time in making the meeting successful. The feedback that we received from our webinar audience in particular was very positive, and demonstrated interest in further considering your presentations. We are preparing to post them on the meeting web site (a bit behind schedule).

If the version you sent me before the meeting is fine to be posted, you don't need to do anything further. If you have any concerns with posting some of the slides (e.g. results too premature, future publication,…), please send me a redacted version by Tuesday 1/17. If you need more time, please let me know.

Best

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Lawrence, Joy[lawrence@hsph.harvard.edu]; Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Wed 1/11/2017 3:15:28 PM
Subject: Reminder of report coming due for your STAR grant

Dear Petros,

I hope the New year is starting well for you. This is a reminder that the annual report for your STAR grant 835755 will be due on February 1st.

Guidance for the format of the report can be found under the Terms and Conditions applicable to your award, at https://www.nsf.gov/pubs/policydocs/rtc/agencyspecifics/epa_314.pdf - under Article 8, section A.

Thank you for your attention to this deadline.

Best

Vito

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Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Fri 12/30/2016 6:26:33 PM
Subject: Funding request for 2017

Dear Petros,

When possible, please send me a request for another year of Center funding for 2017. This is the usual request on letterhead, indicating whether or not everything is proceeding satisfactorily, and whether these funds are needed for the project.

I will assume the previous budget still applies, but you can follow up with a revised one later, if appropriate.

Thank you and Happy 2017!

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Washington, DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Smythe, Alice[asmythe@hsph.harvard.edu]
From: Ilacqua, Vito
Sent: Tue 12/6/2016 2:06:23 PM
Subject: FW: Logistical information for next week's meeting in DC

Good morning Petros,

Due to the logistics of this meeting, not at our site, we need to compile a master slide deck in advance. Please send me your presentation (and Jeremy's if separate) as soon as possible.

Looking forward to seeing you tomorrow.

Thank you

Vito

From: Ilacqua, Vito
Sent: Thursday, December 01, 2016 3:57 PM
To: 'dsailor@asu.edu' <dsailor@asu.edu>; 'Howard Kipen' <kipen@eohsi.rutgers.edu>; 'Koutrakis, Petros' <petros@hsph.harvard.edu>; 'jsarnat@emory.edu' <jsarnat@emory.edu>; 'Smythe, Alice' <asmythe@hsph.harvard.edu>; 'gcm@mst.edu' <gcm@mst.edu>; 'brent@iit.edu' <brent@iit.edu>; Breen, Michael <Breen.Michael@epa.gov>; 'Lamb, Brian K' <blamb@wsu.edu>; 'tjobson@wsu.edu' <tjobson@wsu.edu>; 'Tonn, Bruce E' <btonn@utk.edu>; 'shelly.miller@colorado.edu' <shelly.miller@colorado.edu>; G Brown <gzbrown@uoregon.edu>; 'ckuejio@gmail.com' <ckuejio@gmail.com>
Subject: Logistical information for next week's meeting in DC

Dear participants,

Here are the promised logistical details for you. I have also attached the final (hopefully!) version of the agenda. You may notice I had to re-arrange the timing of several presentations compared to earlier drafts. Feel free to share webinar registration information and agenda with those you think may be interested.

Just a few details to help you plan the meeting days:

• The meeting site is about 30 min from the hotel, by public transportation or walking (slightly faster). Please plan accordingly.

• The closest Metro stop to the meeting site is Shaw-Howard (Yellow-Green line). The best Metro stop from the hotel is Farragut North (Red line). There are of course alternative transportation options.

• For any unforeseen events on the meeting days, my cell phone is 732 343 2614

• Lunch is on your own, but there are nearby eateries

• We plan on having dinner together after the first day. Please confirm if you are interested.

If you have not done so yet, please send your slides to me by COB Monday.

Should you have any other questions, do call or email me.

Thank you very much

Vito

Science to Achieve Results (STAR): Indoor Air & Climate Change Progress Review Meeting

Location: Interdisciplinary Research Building at Howard University

Address: 2201 Georgia Ave NW, Washington, DC 20059 (Multi-purpose Room – 106 A)

Website: http://www.howard.edu/expandingthecapstone/researchbldg.htm

Wednesday, December 7, 9-4:30PM EST

Thursday, December 8, 9-12:30PM EST

Click here to register for the webinar (Registration is FREE):

Day One: https://attendee.gotowebinar.com/register/3278455980999258113

Day Two: https://attendee.gotowebinar.com/register/1884063031235151617

Vito A. Ilacqua, Ph.D.

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To: dsailor@asu.edu[dsailor@asu.edu]; Howard Kipen[kipen@eohsi.rutgers.edu]; Koutrakis, Petros[petros@hsph.harvard.edu]; jsarnat@emory.edu[jsarnat@emory.edu]; Smythe, Alice[asmythe@hsph.harvard.edu]; gcm@mst.edu[gcm@mst.edu]; brent@iit.edu[brent@iit.edu]; Breen, Michael[Breen.Michael@epa.gov]; Lamb, Brian K[blamb@wsu.edu]; tjobson@wsu.edu[tjobson@wsu.edu]; Tonn, Bruce E[btonn@utk.edu]; shelly.miller@colorado.edu[shelly.miller@colorado.edu]; G Brown[gzbrown@uoregon.edu]; ckuejio@gmail.com[ckuejio@gmail.com]
From: Ilacqua, Vito
Sent: Thur 12/1/2016 8:56:47 PM
Subject: Logistical information for next week's meeting in DC
STAR Grants Progress Review 12-7and 8 2016- Agenda.docx

Dear participants,

Here are the promised logistical details for you. I have also attached the final (hopefully!) version of the agenda. You may notice I had to re-arrange the timing of several presentations compared to earlier drafts. Feel free to share webinar registration information and agenda with those you think may be interested.

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Indoor Air in a Changing Climate: EPA STAR Grants Research

STAR Grants Progress Review Meeting - Agenda
Interdisciplinary Research Building at Howard University (Georgia Avenue and W Street, NW)
December 7-8, 2016

Wednesday, December 7, 2016

9:00-9:05	Vito Ilacqua	Meeting and webinar logistic
9:05-9:10	Gary Harris *Aso. Provost for Research*	Welcome to Howard University
9:10-9:15	James Johnson *Director, NCER*	EPA and Howard University partnership
9:15-9:30	Mike Flynn *EPA Associate Deputy Administrator*	Introduction: indoor air and EPA
9:30-9:45	Darrell Winner *ORD Air Climate & Energy National Program*	Introduction: Air Climate and Energy program
9:45-10:15	Howard Kipen *Rutgers University*	Climate Change, Indoor Ozone and Vascular Function
10:15-10:45	Break	
10:45-11:15	David Sailor *Arizona State University*	Determinants of Indoor and Outdoor Exposure to Ozone and Extreme Heat in a Warming Climate and the Health Risks for an Aging Population
11:15-11:45	P. Koutrakis & J. Sarnat *Harvard University & Emory U.*	Assessing the Potential Impact of Global Warming on Indoor Air Quality and Human Health in Two US Cities: Boston, MA and Atlanta, GA
11:45-12:15	Laura Kolb *EPA – Office of Radiation and Indoor Air*	Perspectives from EPA, Indoor Environments Division
12:15-13:30	Lunch	
13:30-14:00	Glenn Morrison *Missouri University of Science & Technology*	Indoor Exposure to Pollutants Associated with Oxidative Chemistry: Field Studies and Window-Opening Behavior
14:00-14:30	W. Stuart Dols *National institute of Standards and Technology*	Research with the CONTAM model
14:30-15:00	Brent Stephens *Illinois Institute of Science & Technology*	Combining Measurements and Models to Predict the Impacts of Climate Change and Weatherization on Indoor Air Quality and Chronic Health Effects in U.S. Residences
15:00-15:30	Break	
15:30-16:00	Mike Breen *EPA – National Exposure Research Lab*	Air pollution infiltration and exposure modeling for health studies and climate change
16:00-16:30	Brian Lamb & Tom Jobson *Washington State University*	Integrated Measurements and Modeling Using US Smart Homes to Assess Climate Change Impacts on Indoor Air Quality

18:00 Optional Dinner at TBD

Thursday, December 8 2016

9:00-9:20	Allison Crimmins *EPA – OAR/OAP*	Assessments of Climate Change and Human Health Research
9:20-9:50	Joshua Olsen & Bruce Tonn *Dept. of Energy U. Tenn. Knoxville*	The DOE Weatherization Assistance Program
9:50-10:20	Shelly Miller *University of Colorado - Boulder*	Climate Change Mitigation in Low-Income Communities in Colorado: Home Weatherization Impacts on Respiratory Health and Indoor Air Quality during Wildfires
10:20-10:50	GZ Brown *University of Oregon*	Impacts of Weatherization on Microbial Ecology and Human Health
10:50-11:15	Break	
11:15-11:30	Andrew Kreider *EPA Region 3*	A regional EPA perspective on climate change
11:30-12:00	Christopher Uejio *Florida State University*	Indoor Environment and Emergency Response Health Outcomes
12:00-12:20	Andy Miller *EPA, Associate NPD for Climate*	Conclusions and future directions
12:20	Adjourn	

Indoor Air in a Changing Climate: EPA STAR Grants Research

Registration, Directions, and Webinar Information

Wednesday and Thursday, December 7-8, 2016

Registration and webinar information

Day One: https://attendee.gotowebinar.com/register/3278455980999258113

Day Two: https://attendee.gotowebinar.com/register/1884063031235151617

To: G Brown[gzbrown@uoregon.edu]; Howard Kipen[kipen@eohsi.rutgers.edu]; Koutrakis, Petros[petros@hsph.harvard.edu]; jsarnat@emory.edu[jsarnat@emory.edu]; Smythe, Alice[asmythe@hsph.harvard.edu]; Lamb, Brian K[blamb@wsu.edu]; shelly.miller@colorado.edu[shelly.miller@colorado.edu]; gcm@mst.edu[gcm@mst.edu]; dsailor@asu.edu[dsailor@asu.edu]; brent@iit.edu[brent@iit.edu]; ckuejio@gmail.com[ckuejio@gmail.com]
Cc: Cristina Cordova[ccordova@scgcorp.com]; Kolb, Laura[Kolb.Laura@epa.gov]
From: Ilacqua, Vito
Sent: Wed 11/16/2016 4:22:52 PM
Subject: More details on the Dec 7-8 STAR grant meeting
STAR Grants Progress Review 12-7and 8 2016- Agenda.docx

Dear STAR grantees,

We are 3 weeks away from our meeting and there's still much to do. I wanted to share with you the latest draft of the meeting agenda, to give you a sense of the meeting structure and what is expected from you, and also get your feedback. In particular, there is a bit of time on the agenda for additional activities, such as panel discussions, or other opportunities for you and the other speakers to interact – perhaps simply during longer breaks. Rather than just deciding to do so, I'd like your thoughts on whether you would find this time useful, or perhaps even have specific ideas for activities or discussions that you'd like to see included.

If you'd like to hear from non-grantee speakers (EPA, NIST, DoE) about a specific issue, please let me know and I can ask them to address it, though I can't guarantee.

To prepare your presentation:

•□□□□□□□□ The current agenda allots 30 min to each project, including Q&A time (about 5 min). There may still be adjustments to this time, but minor ones.

•□□□□□□□□ This is a technical meeting but the audience typically has a variety of backgrounds, so you can go in some detail about your methods and results so far, but do include a non-technical introduction about the project goals and structure.

•□□□□□□□□ If you plan to share your presentation time with co-PIs or others, please let me know, so we can add their names to the agenda.

•□□□□□□□□ Reminder: the meeting is public and will be webcast to anyone who registers.

By COB **Monday, Dec 5th, please send me a copy of your presentation**. Presentations will eventually be made public on our website, but we are mindful of concerns you may have for future publications or other reasons, so you can send me a redacted version for that purpose.

Directions will follow in later messages. Let me know if you have any other questions.

Thank you

Vito

Vito A. Ilacqua, Ph.D.

Physical Scientist

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National Center for Environmental Research | ORD | US Environmental Protection Agency
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Washington, DC 20460

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1300 Pennsylvania Avenue NW

Washington, DC 20004

Indoor Air in a Changing Climate: EPA STAR Grants Research

December 7-8, 2016 – One of the high-priority research areas identified by the U.S. Environmental Protection Agency's Office of Research and Development (ORD) involves the interaction between issues of air quality, climate, and energy, which can impact human health and the environment. To advance its statutory mission, and recognizing the continuity between indoor and outdoor air quality, the U.S. Environmental Protection Agency Office of Research and Development, National Center for Environmental Research (NCER), funded research in 9 institutions through STAR grants to improve understanding of the effects of climate change on indoor air quality and the resulting health effects. The primary goal of this research is to explore the anticipated effects of climate change on indoor air quality directly through a variety of mechanisms, and indirectly through adaptations in building use and design.

This progress review meeting brings together grantees, and researchers and policy makers from EPA and other federal agencies to discuss findings and implications and develop further collaborations.

STAR Grants Progress Review Meeting - Agenda
Interdisciplinary Research Building at Howard University (Georgia Avenue and W Street, NW)
December 7-8, 2016
###Link to webpage

Wednesday, December 7, 2016

9:00-9:10	Vito Ilacqua	Meeting and webinar logistic
9:10-9:20	Gary Harris (TBC) *Title to be confirmed*	Welcome to Howard University
9:20-9:35	Mike Flynn *EPA Associate Deputy Administrator*	Introduction: indoor air and EPA
9:35-9:55	Dan Costa *National Program Director, Air Climate & Energy*	Introduction: Air Climate and Energy program
9:55-10:25	Glenn Morrison *Missouri University of Science & Technology*	Indoor Exposure to Pollutants Associated with Oxidative Chemistry: Field Studies and Window-Opening Behavior
10:25-10:40	Break	
10:40-11:10	Howard Kipen *Rutgers University*	Climate Change, Indoor Ozone and Vascular Function
11:10-11:40	Laura Kolb *EPA – Office of Radiation and Indoor Air*	TBC – e.g. Significance and genesis of climate change and indoor air questions
11:40-12:10	Christopher Uejio *Florida State University*	Indoor Environment and Emergency Response Health Outcomes
12:10-13:20	Lunch	
13:20-13:50	Shelly Miller *University of Colorado - Boulder*	Climate Change Mitigation in Low-Income Communities in Colorado: Home Weatherization Impacts on Respiratory Health and Indoor Air Quality during Wildfires
13:50-14:20	TBD *Department of Energy*	DoE weatherization program
14:20-14:50	Brian Lamb *Washington State University*	Integrated Measurements and Modeling Using US Smart Homes to Assess Climate Change Impacts on Indoor Air Quality
14:50-15:05	Break	
15:05-15:35	Mike Breen *EPA – National Exposure Research Lab*	TBC – example of indoor air and exposure research at EPA
15:35-16:05	Brent Stephens *Illinois Institute of Science & Technology*	Combining Measurements and Models to Predict the Impacts of Climate Change and Weatherization on Indoor Air Quality and Chronic Health Effects in U.S. Residences

18:30 Optional Dinner at TBD

Thursday, December 8 2016

9:00-9:20	TBD *EPA – OAR/OAP*	TBD - An OAP perspective on climate change
9:20-9:50	Petros Koutrakis *Harvard University*	Assessing the Potential Impact of Global Warming on Indoor Air Quality and Human Health in Two US Cities: Boston, MA and Atlanta, GA
9:50-10:20	W. Stuart Dols *National institute of Standards and Technology*	TBC: research with the CONTAM model
10:20-10:50	David Sailor *Arizaona State University*	Determinants of Indoor and Outdoor Exposure to Ozone and Extreme Heat in a Warming Climate and the Health Risks for an Aging Population
10:50-11:05	Break	
11:05-11:20	Megan Goold (TBC) *EPA Region 3*	TBD: A regional EPA perspective
11:20-11:50	GZ Brown *University of Oregon*	Impacts of Weatherization on Microbial Ecology and Human Health
11:50-12:10	Darrell Winner? *EPA*	Summary and future directions
12:10	Adjourn	

Presentation list

(by presenter, in alphabetical order)

Presentations will be available after the meeting

Indoor Air in a Changing Climate: EPA STAR Grants Research

Registration, Directions, and Webinar Information

Wednesday and Thursday, December 7-8, 2016

Registration and webinar information

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Mon 5/15/2017 12:54:23 AM
Subject: RE: ACE Centers Meeting, agenda suggestions

This looks fine to me see you soon

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, May 11, 2017 3:14 PM
To: Bell, Michelle <michelle.bell@yale.edu>; Jones, Diana <diana.jones@yale.edu>; Koutrakis, Petros <petros@hsph.harvard.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Katherine Tucker <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <Costa.Dan@epa.gov>
Subject: RE: ACE Centers Meeting, agenda suggestions

Hi All,

This is a reminder to have a look at the agenda. So far the only feedback I've received has been from Alice regarding logistics. Lots of EPA people are asking about this.

I'd especially like to know if Julien and Michelle are okay with the additional topics that I assigned to them.

Thanks for your quick response!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Hunt, Sherri
Sent: Friday, May 05, 2017 12:28 PM
To: 'Bell, Michelle' <michelle.bell@yale.edu>; 'Jones, Diana' <diana.jones@yale.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; 'Julian Marshall' <jdmarsh@uw.edu>; 'Katherine Tucker' <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <ilacqua.vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <costa.dan@epa.gov>
Subject: ACE Centers Meeting, agenda suggestions

Hi All,

Based on the discussion at our last directors call, I've developed the attached revised the meeting agenda. Please provide feedback to the items below and anything else to me as soon as possible. Let's make a hard deadline of next Friday, May 12.

A couple of items are worth specific note:

(in no particular order, some logistical and some content)

1. I kept Center presentation times at 60 minutes, but allocated a shorter time for EPA updates. Is everyone ok with this?

2. I decided to give the Harvard Center the acronym RAPM (pronounced rap-em). This can be rejected without consequences.

3. Do we want to include speaker names on the agenda? I expect each Center may have

multiple speakers. I'm happy to do whatever, but suggest consistency so if we are including names, I need to know what they are.

4. The Collaborative Project Brainstorming/Discussion groups are simply suggestions. I think it makes sense to have people from the Centers lead these since most successful projects have a champion working on them. If we are going to do this, I need your feedback on the topics and the leaders. NCER and EPA will be happy to participate in the discussion and support with notetaking.

5. I kept the hour between the poster session and reception, but is it needed?

6. Are we already committed to a start time for the reception on June 1?

7. On June 2, I likely need corrections to the speakers for the morning talks. Also, is this a good grouping? Any changes to suggest?

8. June 2 also includes a block of time which could be for more collaborative discussions or for meetings within each Center (since two of them are geographically dispersed). Which do you prefer?

9. We should identify a closing discussion leader and some key questions on points to be made. Suggestions?

Thanks a bunch.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

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To: Alice Smythe[asmythe@hsph.harvard.edu]; Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Tue 5/9/2017 12:17:05 AM
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

I think they should be responsible for the rooms they asked for

From: Smythe, Alice
Sent: Monday, May 8, 2017 10:19 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Hi, it's 25 but EPA is only 2 away from fulfilling 80% of the government rate room block which is good. If 2 more sign up we'll be looking good.

We are quite put out by the fact that the CMU group told us that their estimate could go as high as 35 – so I put them down for 25 to be safe but I got an email on Friday from Kate saying that only about 8 are going. Anyway, I will try like heck to sweet talk the hotel into forgiving some of our commitment but it's a legal contract and they may not go for it. This is the first time we've ever had this problem.

Hi Alice,

I have heard from 20 people that they are likely to attend. We have not heard back from 15 people, so our headcount could be as high as 35. I estimate that we'll end up with 20 – 30 CACES representatives. I hope this is helpful!

Thank you,

Kate

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Monday, May 08, 2017 10:03 AM
To: Smythe, Alice
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Thanks, Alice. What was our commitment for rooms?

Have you been getting needed info from other Centers?

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, May 08, 2017 8:26 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: FW: New guest Michael Gonzalez for GOVT rate room block

Sherri, latest EPA annual meeting hotel rooming list.

Thanks

Alice

From: Fabrina Pena-Guzman [mailto:fabrina.guzman@lemeridiencambridge.com]
Sent: Friday, May 05, 2017 12:43 PM
To: Smythe, Alice
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Hi Alice,

Please find attached the updated rooming list with all your additions from yesterday.

Let me know if you have any questions. Have a wonderful weekend!

My best,

Fabrina Peña-Guzman

Conference Services Manager
T +1 617 551 0312   F +1 617 551 0444

fabrina.guzman@lemeridiencambridge.com

N 42°21' W 71°6'

LE MERIDIEN
CAMBRIDGE - MIT

20 Sidney Street, Cambridge, MA 02139 USA

lemeridien.com/cambridge

[FACEBOOK](#) [TWITTER](#) [INSTAGRAM](#)

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Thursday, May 04, 2017 12:58 PM
To: Fabrina Pena-Guzman
Subject: New guest Michael Gonzalez for GOVT rate room block

Hi Fabrina,

Please add Michael Gonzalez to the government rate room block for 2 nights – checking in May 31, checking out June 2.

Thank you very much,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

https://sites.sph.harvard.edu/ace/

This email has been scanned by the Symantec Email Security.cloud service.
For more information please visit http://www.symanteccloud.com

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Wed 5/3/2017 1:53:52 AM
Subject: Re: Hei

Sounds great
And I will tell you the research secret

Sent from my iPhone

On May 2, 2017, at 2:13 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

> :)
>
> I'll let you know my schedule soon.
>
> Regards,
> Sherri Hunt
> 571.339.9491
>
> Sent from my iPhone
>
> On May 2, 2017, at 9:42 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:
>
>> I know you have many responsibilities
>>
>> I am in Boston
>>
>> I have some important meetings and I had to leave
>>
>> If you have time to go for dinner when you come to Boston I will be happy to go out with you and other epa folks if they wish
>>
>> **From:** Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
>> **Sent:** Tuesday, May 2, 2017 9:34 AM
>> **To:** Koutrakis, Petros <petros@hsph.harvard.edu>
>> **Cc:** Smythe, Alice <asmythe@hsph.harvard.edu>
>> **Subject:** Re: Hei

Same. It's always hard for local meetings and small kids.

Are you leaving? I'll be here all day.

Regards,

Sherri Hunt

571.339.9491

Sent from my iPhone

On May 2, 2017, at 9:31 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

Sherri it was nice seeing you sorry we did not have the chance to chat much

The invitation was sent to HEI

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Monday, May 1, 2017 11:50 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Re: Hei

You can.

No preference.

Regards,

Sherri Hunt

571.339.9491

Sent from my iPhone

On May 1, 2017, at 11:39 AM, Koutrakis, Petros <petros@hsph.harvard.edu>
wrote:

> Great do you want to invite them?
> Or do you want me to ask them
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> Sent from my iPhone
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> > wrote:
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> > To attend - definitely.
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> > ---
> >
> > Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
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> >
> > Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R)
> > Washington DC 20460
> >
> > Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine

M312K) Washington DC 20004

-----Original Message-----

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, May 01, 2017 10:28 AM

To: Hunt, Sherri <Hunt.Sherri@epa.gov>

Subject: Hei

Can we invite hei to the annual meeting?

It is a shame because they are local.

Sent from my iPhone

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Tue 5/2/2017 1:37:07 PM
Subject: RE: Hei

I know you have many responsibilities

I am in Boston

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Sent: Tuesday, May 2, 2017 9:34 AM
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Cc: Smythe, Alice <asmythe@hsph.harvard.edu>
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Sherri

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
Cc: Alice Smythe[asmythe@hsph.harvard.edu]
From: Koutrakis, Petros
Sent: Tue 5/2/2017 1:29:31 PM
Subject: RE: Hei

Sherri it was nice seeing you sorry we did not have the chance to chat much

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From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Monday, May 1, 2017 11:50 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Re: Hei

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No preference.

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Sherri Hunt

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Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Washington DC 20004

-----Original Message-----

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, May 01, 2017 10:28 AM

To: Hunt, Sherri <Hunt.Sherri@epa.gov>

Subject: Hei

Can we invite hei to the annual meeting?

It is a shame because they are local.

Sent from my iPhone

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Mon 5/1/2017 3:37:33 PM
Subject: Re: Hei

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Sent from my iPhone

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Mon 5/1/2017 2:27:32 PM
Subject: Hei

Can we invite hei to the annual meeting?
It is a shame because they are local.

Sent from my iPhone

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Thur 4/27/2017 6:24:49 PM
Subject: RE: ACE Centers Annual Meeting

I do not understand this negativity

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:05 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Bell, Michelle <michelle.bell@yale.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Baxter, Lisa <Baxter.Lisa@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Roger Peng <rdpeng@jhu.edu>
Subject: FW: ACE Centers Annual Meeting

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>

Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Ilacqua, Vito[ilacqua.vito@epa.gov]; Callan, Richard[/o=ExchangeLabs/ou=Exchange Administrative Group (FYDIBOHF23SPDLT)/cn=Recipients/cn=7e7e051eb3e74f3eac0876cab7e3eb16-callan, richard]; Katz, Taylor[Katz.Taylor@epa.gov]; Costa, Dan[costa.dan@epa.gov]; Alan Vette (Vette.Alan@epa.gov)[Vette.Alan@epa.gov]; Miller, Andy[Miller.Andy@epa.gov]; Hassett-Sipple, Beth[Hassett-Sipple.Beth@epa.gov]; Bell, Michelle[michelle.bell@yale.edu]; Roger Peng[rdpeng@jhu.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Jones, Diana[diana.jones@yale.edu]; Hunt, Sherri[Hunt.Sherri@epa.gov]
Cc: Baxter, Lisa[Baxter.Lisa@epa.gov]; Grambsch, Anne[Grambsch.Anne@epa.gov]; Hagler, Gayle[Hagler.Gayle@epa.gov]; Nunez, Carlos[Nunez.Carlos@epa.gov]
From: Hunt, Sherri
Sent: Fri 12/2/2016 4:07:45 PM
Subject: ACE Center Directors Call

Hi All,

Thanks for joining us yesterday. As discussed, at our next call Petros will bring a draft agenda for the June 1-2 meeting and everyone will be thinking of speakers we may want to invite or ways to encourage useful discussion among scientists within the Centers and EPA. I would also like to share research progress updates at that time as well.

I incorrectly noted the time for our next call – we are currently scheduled at talk at 2 pm on the 4th Thursday of the month, i.e. Jan. 26, Feb 23, March 23, April 27..

I hope that everyone has a fun and restful holiday

All the best,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Wed 4/26/2017 5:44:36 PM
Subject: Re: ACE Centers Annual Meeting

No it is ok to ask her
She is on line but I just wanted to let you know why was not around

Looking forward seeing soon

Sent from my iPhone

On Apr 26, 2017, at 1:41 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

> Oh no!
>
> I'm so sorry to hear about this. Alice feels like family to me and I'm sure this feeling is even stronger for you.
>
> I'll hold any other questions that come up. I only seem to have a draft agenda.
>
> Sherri
>
> ---
>
> Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 1:29 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: ACE Centers Annual Meeting

Hi Sherri

Alice has been battling with cancer

She had two clots in the lungs and stayed at the hospital for eight days

She was out yesterday and is starting to take care of her emails

I thought we finalized the agenda

We are set but the only big issue is room vacancy

We will need to talk tomorrow

Sent from my iPhone

On Apr 26, 2017, at 1:24 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

> Hi Petros and Alice,
>
> We are scheduled to have a Center Directors' call tomorrow afternoon. Can you please let me know if you feel ready for the annual meeting or whether there are issues to discuss? Also, do we have a final agenda? (Several EPA folks have asked me for this.)
>
> Thanks,
>
> Sherri
>
> ---
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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Wed 4/26/2017 5:29:13 PM
Subject: Re: ACE Centers Annual Meeting

Hi Sherri
Alice has been battling with cancer
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I thought we finalized the agenda
We are set but the only big issue is room vacancy
We will need to talk tomorrow

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Wed 2/1/2017 1:35:18 AM
Subject: RE: Quick question

Sherri forgot to call you

Sorry but I just realized

I called today before 10 but no answer

I teach from 10.30 to 12.30 but I am flexible for the rest of the day

Just let me know what is a good time to call you

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Tuesday, January 31, 2017 9:31 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Quick question

Yes – please.

Sherri

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Tuesday, January 31, 2017 9:19 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: Quick question

Sure I will call

I can call now before 10 if you wish

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Tuesday, January 31, 2017 9:13 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Quick question

Hi Petros,

I have a quick question for you. I'm scheduled to be in meetings today from 10 am to 4 pm, but available later. Please give me a call if you have time late this afternoon or tomorrow.
571.339.9491 (cell)

Thanks.

Sherri

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Tue 1/31/2017 2:19:14 PM
Subject: RE: Quick question

Sure I will call

I can call now before 10 if you wish

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Tuesday, January 31, 2017 9:13 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Quick question

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Dominici, Francesca
Sent: Wed 6/28/2017 6:48:49 PM
Subject: Re: NEJM paper?

happy reading :)

FRANCESCA DOMINICI, PHD |
co-Director of the Harvard Data Science Initiative
Professor of Biostatistics | Department of Biostatistics
Harvard T.H. Chan School of Public Health
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fdominic@hsph.harvard.edu
http://www.hsph.harvard.edu/francesca-dominici/

For appointments and scheduling please contact
Joan Elizabeth Whalen
Email: jwhalen@hsph.harvard.edu

On Jun 28, 2017, at 2:45 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Thank you!

Sherri

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Dominici, Francesca [mailto:fdominic@hsph.harvard.edu]
Sent: Wednesday, June 28, 2017 2:43 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: NEJM paper?

here is it + HSPH press release
the NEJM editorial is powerful
just keep in mind that this is embargoed until 5 pm today
we are getting a lot of press attention

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Email: jwhalen@hsph.harvard.edu

On Jun 28, 2017, at 2:35 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Hi Francesca,

I heard about your paper during an HEI call today. It sounds like people are quite excited. I'm wondering whether you can send a copy – I'll like to write something for our communications team to add to the note that goes out on Friday.

(I do understand if you want to wait until tomorrow though.)

Regards,
Sherri

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To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Dominici, Francesca
Sent: Wed 6/28/2017 6:43:07 PM
Subject: Re: NEJM paper?
17062906.pdf
17062915.pdf
Press release_Francesca Air Pollution and Seniors_6.19.17_TD copy.docx

here is it + HSPH press release
the NEJM editorial is powerful
just keep in mind that this is embargoed until 5 pm today
we are getting a lot of press attention

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The new england journal of medicine

ESTABLISHED in 1812 June 29, 2017 vol. 376 no. 26

Air Pollution and Mortality in the Medicare Population

Qian Di, M.S., Yan Wang, M.S., Antonella Zanobetti, Ph.D., Yun Wang, Ph.D., Petros Koutrakis, Ph.D., Christine Choirat, Ph.D., Francesca Dominici, Ph.D., and Joel D. Schwartz, Ph.D.

ABSTRACT

BACKGROUND

Studies have shown that long-term exposure to air pollution increases mortality. However, evidence is limited for air-pollution levels below the most recent National Ambient Air Quality Standards. Previous studies involved predominantly urban populations and did not have the statistical power to estimate the health effects in underrepresented groups.

METHODS

We constructed an open cohort of all Medicare beneficiaries (60,925,443 persons) in the continental United States from the years 2000 through 2012, with 460,310,521 person-years of follow-up. Annual averages of fine particulate matter (particles with a mass median aerodynamic diameter of less than 2.5 μm [$PM_{2.5}$]) and ozone were estimated according to the ZIP Code of residence for each enrollee with the use of previously validated prediction models. We estimated the risk of death associated with exposure to increases of 10 μg per cubic meter for $PM_{2.5}$ and 10 parts per billion (ppb) for ozone using a two-pollutant Cox proportional-hazards model that controlled for demographic characteristics, Medicaid eligibility, and area-level covariates.

RESULTS

Increases of 10 μg per cubic meter in $PM_{2.5}$ and of 10 ppb in ozone were associated with increases in all-cause mortality of 7.3% (95% confidence interval [CI], 7.1 to 7.5) and 1.1% (95% CI, 1.0 to 1.2), respectively. When the analysis was restricted to person-years with exposure to $PM_{2.5}$ of less than 12 μg per cubic meter and ozone of less than 50 ppb, the same increases in $PM_{2.5}$ and ozone were associated with increases in the risk of death of 13.6% (95% CI, 13.1 to 14.1) and 1.0% (95% CI, 0.9 to 1.1), respectively. For $PM_{2.5}$, the risk of death among men, blacks, and people with Medicaid eligibility was higher than that in the rest of the population.

CONCLUSIONS

In the entire Medicare population, there was significant evidence of adverse effects related to exposure to $PM_{2.5}$ and ozone at concentrations below current national standards. This effect was most pronounced among self-identified racial minorities and people with low income. (Supported by the Health Effects Institute and others.)

From the Departments of Environmental Health (Q.D., Yan Wang, A.Z., P.K., J.D.S.) and Biostatistics (Yun Wang, C.C., F.D.), Harvard T.H. Chan School of Public Health, Boston. Address reprint requests to Dr. Dominici at Harvard T.H. Chan School of Public Health, Biostatistics Department, Bldg. 2, 4th Flr., 655 Huntington Ave., Boston, MA 02115, or at fdominic@hsph.harvard.edu.

N Engl J Med 2017;376:2513-22.
DOI: 10.1056/NEJMoa1702747

The adverse health effects associated with long-term exposure to air pollution are well documented.[1,2] Studies suggest that fine particles (particles with a mass median aerodynamic diameter of less than 2.5 μm [$PM_{2.5}$]) are a public health concern,[3] with exposure linked to decreased life expectancy.[4-6] Long-term exposure to ozone has also been associated with reduced survival in several recent studies, although evidence is sparse.[4,7-9]

A Quick Take is available at NEJM.org

Studies with large cohorts have investigated the relationship between long-term exposures to $PM_{2.5}$ and ozone and mortality[4,9-13]; others have estimated the health effects of fine particles at low concentrations (e.g., below 12 μg per cubic meter for $PM_{2.5}$).[14-18] However, most of these studies have included populations whose socioeconomic status is higher than the national average and who reside in well-monitored urban areas. Consequently, these studies provide limited information on the health effects of long-term exposure to low levels of air pollution in smaller cities and rural areas or among minorities or persons with low socioeconomic status.

To address these gaps in knowledge, we conducted a nationwide cohort study involving all Medicare beneficiaries from 2000 through 2012, a population of 61 million, with 460 million person-years of follow-up. We used a survival analysis to estimate the risk of death from any cause associated with long-term exposure (yearly average) to $PM_{2.5}$ concentrations lower than the current annual National Ambient Air Quality Standard (NAAQS) of 12 μg per cubic meter and to ozone concentrations below 50 parts per billion (ppb). Subgroup analyses were conducted to identify populations with a higher or lower level of pollution-associated risk of death from any cause.

METHODS

MORTALITY Data

We obtained the Medicare beneficiary denominator file from the Centers for Medicare and Medicaid Services, which contains information on all persons in the United States covered by Medicare and more than 96% of the population 65 years of age or older. We constructed an open cohort consisting of all beneficiaries in this age group in the continental United States from 2000 through 2012, with all-cause mortality as the outcome. For each beneficiary, we extracted the date of death (up to December 31, 2012), age at year of Medicare entry, year of entry, sex, race, ZIP Code of residence, and Medicaid eligibility (a proxy for low socioeconomic status). Persons who were alive on January 1 of the year following their enrollment in Medicare were entered into the open cohort for the survival analysis. Follow-up periods were defined according to calendar years.

ASSESSMENT of Exposure to Air Pollution

Ambient levels of ozone and $PM_{2.5}$ were estimated and validated on the basis of previously published prediction models.[19,20] Briefly, we used an artificial neural network that incorporated satellite-based measurements, simulation outputs from a chemical transport model, land-use terms, meteorologic data, and other data to predict daily concentrations of $PM_{2.5}$ and ozone at unmonitored locations. We fit the neural network with monitoring data from the Environmental Protection Agency (EPA) Air Quality System (AQS) (in which there are 1928 monitoring stations for $PM_{2.5}$ and 1877 monitoring stations for ozone). We then predicted daily $PM_{2.5}$ and ozone concentrations for nationwide grids that were 1 km by 1 km. Cross-validation indicated that predictions were good across the entire study area. The coefficients of determination (R^2) for $PM_{2.5}$ and ozone were 0.83 and 0.80, respectively; the mean square errors between the target and forecasting values for $PM_{2.5}$ and ozone were 1.29 μg per cubic meter and 2.91 ppb, respectively. Data on daily air temperature and relative humidity were retrieved from North American Regional Reanalysis with grids that were approximately 32 km by 32 km; data were averaged annually.[21]

For each calendar year during which a person was at risk of death, we assigned to that person a value for the annual average $PM_{2.5}$ concentration, a value for average ozone level during the warm season (April 1 through September 30), and values for annual average temperature and humidity according to the ZIP Code of the person's residence. The warm-season ozone concentration was used to compare our results with those of previous studies.[10] In this study, "ozone concentration" refers to the average concentration during the warm season, unless specified otherwise.

As part of a sensitivity analysis, we also obtained data on $PM_{2.5}$ and ozone concentrations from the EPA AQS and matched that data with each person in our study on the basis of the nearest monitoring site within a distance of 50 km. (Details are provided in Section 1 in the Supplementary Appendix, available with the full text of this article at NEJM.org.)

STATISTICAL Analysis

We fit a two-pollutant Cox proportional-hazards model with a generalized estimating equation to account for the correlation between ZIP Codes.[22] In this way, the risk of death from any cause associated with long-term exposure to $PM_{2.5}$ was always adjusted for long-term exposure to ozone, and the risk of death from any cause associated with long-term exposure to ozone was always adjusted for long-term exposure to $PM_{2.5}$, unless noted otherwise. We also conducted single-pollutant analyses for comparability. We allowed baseline mortality rates to differ according to sex, race, Medicaid eligibility, and 5-year categories of age at study entry. To adjust for potential confounding, we also obtained 15 ZIP-Code or county-level variables from various sources and a regional dummy variable to account for compositional differences in $PM_{2.5}$ across the United States (Table 1, and Section 1 in the Supplementary Appendix). We conducted this same statistical analysis but restricted it to person-years with $PM_{2.5}$ exposures lower than 12 µg per cubic meter and ozone exposures lower than 50 ppb (low-exposure analysis) (Table 1, and Section 1 in the Supplementary Appendix).

To identify populations at a higher or lower pollution-associated risk of death from any cause, we refit the same two-pollutant Cox model for some subgroups (e.g., male vs. female, white vs. black, and Medicaid eligible vs. Medicaid ineligible). To estimate the concentration-response function of air pollution and mortality, we fit a log-linear model with a thin-plate spline of both $PM_{2.5}$ and ozone and controlled for all the individual and ecologic variables used in our main analysis model (Section 7 in the Supplementary Appendix). To examine the robustness of our results, we conducted sensitivity analyses and compared the extent to which estimates of risk changed with respect to differences in confounding adjustment and estimation approaches (Sections S2 through S4 in the Supplementary Appendix).

Data on some important individual-level covariates were not available for the Medicare cohort, including data on smoking status, body-mass index (BMI), and income. We obtained data from the Medicare Current Beneficiary Survey (MCBS), a representative subsample of Medicare enrollees (133,964 records and 57,154 enrollees for the period 2000 through 2012), with individual-level data on smoking, BMI, income, and many other variables collected by means of telephone survey. Using MCBS data, we investigated how the lack of adjustment for these risk factors could have affected our calculated risk estimates in the Medicare cohort (Section 5 in the Supplementary Appendix). The computations in this article were run on the Odyssey cluster, which is supported by the FAS Division of Science, Research Computing Group, and on the Research Computing Environment, which is supported by the Institute for Quantitative Social Science in the Faculty of Arts and Sciences, both at Harvard University. We used R software, version 3.3.2 (R Project for Statistical Computing), and SAS software, version 9.4 (SAS Institute).

RESULTS

COHORT Analyses

The full cohort included 60,925,443 persons living in 39,716 different ZIP Codes with 460,310,521 person-years of follow-up. The median follow-up was 7 years. The total number of deaths was 22,567,924. There were 11,908,888 deaths and 247,682,367 person-years of follow-up when the $PM_{2.5}$ concentration was below 12 µg per cubic meter and 17,470,128 deaths and 353,831,836 person-years of follow-up when the ozone concentration was below 50 ppb. These data provided excellent power to estimate the risk of death at air-pollution levels below the current annual NAAQS for $PM_{2.5}$ and at low concentrations for ozone (Table 1).

Annual average $PM_{2.5}$ concentrations across the continental United States during the study period ranged from 6.21 to 15.64 µg per cubic meter (5th and 95th percentiles, respectively), and the warm-season average ozone concentrations ranged from 36.27 to 55.86 ppb (5th and 95th percentiles, respectively). The highest $PM_{2.5}$ concentrations were in California and the eastern and southeastern United States. The Mountain region and California had the highest ozone concentrations; the eastern states had lower ozone concentrations (Fig. 1).

Table 1. **Cohort Characteristics and Ecologic and Meteorologic Variables.**

Characteristic or Variable	Entire Cohort	Ozone Concentration		$PM_{2.5}$ Concentration	
		≥50 ppb*	<50 ppb	≥12 μg/m³	<12 μg/m³
Population					
Persons (no.)	60,925,443	14,405,094	46,520,349	28,145,493	32,779,950
Deaths (no.)	22,567,924	5,097,796	17,470,128	10,659,036	11,908,888
Total person-yr†	460,310,521	106,478,685	353,831,836	212,628,154	247,682,367
Median yr of follow-up	7	7	7	7	7
Average air-pollutant concentrations‡					
Ozone (ppb)	46.3	52.8	44.4	48.0	45.3
$PM_{2.5}$ (μg/m³)	11.0	10.9	11.0	13.3	9.6
Individual covariates‡					
Male sex (%)	44.0	44.3	43.8	43.1	44.7
Race or ethnic group (%)§					
White	85.4	86.6	85.1	82.0	88.4
Black	8.7	7.2	9.2	12.0	5.9
Asian	1.8	1.8	1.8	2.1	1.6
Hispanic	1.9	2.0	1.9	1.9	1.9
Native American	0.3	0.6	0.3	0.1	0.6
Eligible for Medicaid (%)	16.5	15.3	16.8	17.8	15.3
Average age at study entry (yr)	70.1	69.7	70.2	70.1	70.0
Ecologic variables‡					
BMI	28.2	27.9	28.4	28.0	28.4
Ever smoked (%)	46.0	44.9	46.2	45.8	46.0
Population including all people 65 yr of age or older (%)					
Hispanic	9.5	13.4	8.4	8.4	10.0
Black	8.8	7.2	9.3	13.3	6.3
Median household income (1000s of $)	47.4	51.0	46.4	47.3	47.4
Median value of housing (1000s of $)	160.5	175.8	156.3	161.7	159.8
Below poverty level (%)	12.2	11.4	12.4	12.5	12.0
Did not complete high school (%)	32.3	30.7	32.7	35.3	30.6
Owner-occupied housing (%)	71.5	71.3	71.6	68.6	73.2
Population density (persons/km²)	3.2	0.7	3.8	4.8	2.2
Low-density lipoprotein level measured (%)	92.2	92.0	92.2	92.2	92.2
Glycated hemoglobin level measured (%)	94.8	94.6	94.8	94.8	94.8
≥1 Ambulatory visits (%)¶	91.7	92.2	91.6	91.7	91.7
Meteorologic variables‡					
Average temperature (°C)	14.0	14.9	13.8	14.5	13.7
Relative humidity (%)	71.1	60.8	73.9	73.7	69.6

* Summary statistics were calculated separately for persons residing in ZIP Codes where average ozone levels were below or above 50 ppb and where $PM_{2.5}$ levels were below or above 12 μg per cubic meter. The value 12 μg per cubic meter was chosen as the current annual National Ambient Air Quality Standard (NAAQS) (e.g., the "safe" level) for $PM_{2.5}$. BMI denotes body-mass index (the weight in kilograms divided by the square of the height in meters) and ppb parts per billion.

† The number for total person-years of follow-up indicates the sum of individual units of time that the persons in the study population were at risk of death from 2000 through 2012.

‡ The average values for air pollution levels and for ecologic and meteorologic variables were computed by averaging values over all ZIP Codes from 2000 through 2012.

§ Data on race and ethnic group were obtained from Medicare beneficiary files.

¶ The variable for ambulatory visits refers to the average annual percentage of Medicare enrollees who had at least one ambulatory visit to a primary care physician.

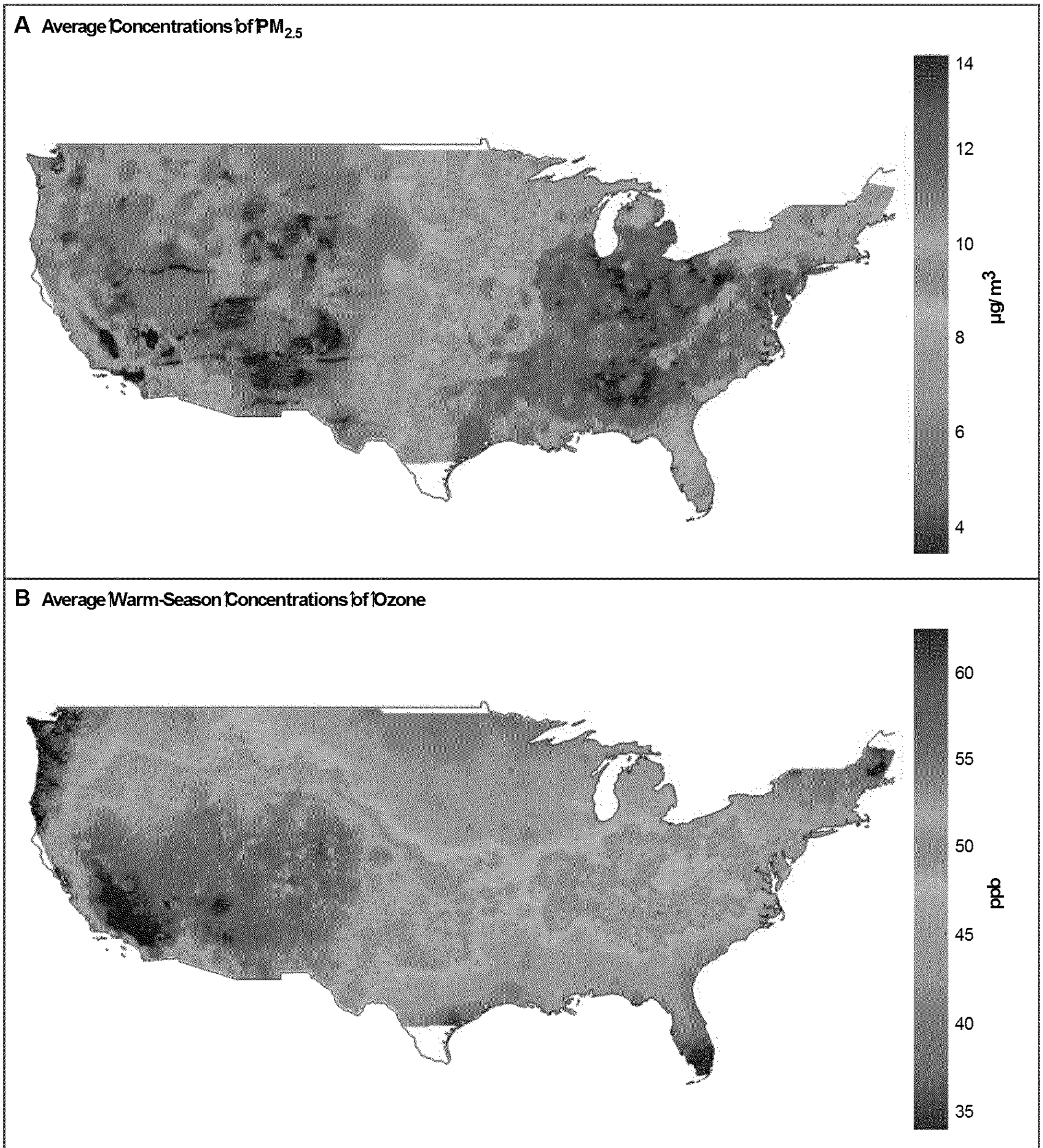

Figure 1. **Average $PM_{2.5}$ and Ozone Concentrations in the Continental United States, 2000 through 2012.**
Panel A shows the average concentrations of fine particulate matter (particles with a mass median aerodynamic diameter of less than 2.5 μm [$PM_{2.5}$]) in micrograms per cubic meter, as estimated on the basis of all daily predictions during the study period. Panel B shows the concentration of ozone levels in parts per billion as averaged from April 1 through September 30 throughout the study period.

In a two-pollutant analysis, each increase of 10 μg per cubic meter in annual exposure to $PM_{2.5}$ (estimated independently of ozone) and each increase of 10 ppb in warm-season exposure to ozone (estimated independently of $PM_{2.5}$) was associated with an increase in all-cause mortality of 7.3% (95% confidence interval [CI], 7.1 to 7.5) and 1.1% (95% CI, 1.0 to 1.2), respectively. Estimates of risk based on predictive, ZIP-Code–specific assessments of exposure were slightly higher than those provided by the nearest data-monitoring site (Table 2). When we restricted the $PM_{2.5}$ and ozone analyses to location-years with low concentrations, we continued to see significant associations between exposure and mortality (Table 2). Analysis of the MCBS

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Table 2. **Risk of Death Associated with an Increase of 10 μg per Cubic Meter in $PM_{2.5}$ or an Increase of 10 ppb in Ozone Concentration.***

Model	$PM_{2.5}$	Ozone
	hazard ratio (95% CI)	
Two-pollutant analysis		
Main analysis	1.073 (1.071–1.075)	1.011 (1.010–1.012)
Low-exposure analysis	1.136 (1.131–1.141)	1.010 (1.009–1.011)
Analysis based on data from nearest monitoring site (nearest-monitor analysis)†	1.061 (1.059–1.063)	1.001 (1.000–1.002)
Single-pollutant analysis‡	1.084 (1.081–1.086)	1.023 (1.022–1.024)

* Hazard ratios and 95% confidence intervals were calculated on the basis of an increase of 10 μg per cubic meter in exposure to $PM_{2.5}$ and an increase of 10 ppb in exposure to ozone.

† Daily average monitoring data on $PM_{2.5}$ and ozone were obtained from the Environmental Protection Agency Air Quality System. Daily ozone concentrations were averaged from April 1 through September 30 for the computation of warm-season averages. Data on $PM_{2.5}$ and ozone levels were obtained from the nearest monitoring site within 50 km. If there was more than one monitoring site within 50 km, the nearest site was chosen. Persons who lived more than 50 km from a monitoring site were excluded.

‡ For the single-pollutant analysis, model specifications were the same as those used in the main analysis, except that ozone was not included in the model when the main effect of $PM_{2.5}$ was estimated and $PM_{2.5}$ was not included in the model when the main effect of ozone was estimated.

subsample provided strong evidence that smoking and income are not likely to be confounders because they do not have a significant association with $PM_{2.5}$ or ozone (Section 5 in the Supplementary Appendix).

SUBGROUP Analyses

Subgroup analyses revealed that men; black, Asian, and Hispanic persons; and persons who were eligible for Medicaid (i.e., those who had low socioeconomic status) had a higher estimated risk of death from any cause in association with $PM_{2.5}$ exposure than the general population. The risk of death associated with ozone exposure was higher among white, Medicaid-eligible persons and was significantly below 1 in some racial subgroups (Fig. 2). Among black persons, the effect estimate for $PM_{2.5}$ was three times as high as that for the overall population (Table S3 in the Supplementary Appendix). Overall, the risk of death associated with ozone exposure was smaller and somewhat less robust than that associated with $PM_{2.5}$ exposure. We also detected a small but significant interaction between ozone exposure and $PM_{2.5}$ exposure (Table S8 in the Supplementary Appendix). Our thin-plate–spline fit indicated a relationship between $PM_{2.5}$, ozone, and all-cause mortality that was almost linear, with no signal of threshold down to 5 μg per cubic meter and 30 ppb, respectively (Fig. 3, and Fig. S8 in the Supplementary Appendix).

DISCUSSION

This study involving an open cohort of all persons receiving Medicare, including those from small cities and rural areas, showed that long-term exposures to $PM_{2.5}$ and ozone were associated with an increased risk of death, even at levels below the current annual NAAQS for $PM_{2.5}$. Furthermore, the study showed that black men and persons eligible to receive Medicaid had a much higher risk of death associated with exposure to air pollution than other subgroups. These findings suggest that lowering the annual NAAQS may produce important public health benefits overall, especially among self-identified racial minorities and people with low income.

The strengths of this study include the assessment of exposure with high spatial and temporal resolution, the use of a cohort of almost 61 million Medicare beneficiaries across the entire continental United States followed for up to 13 consecutive years, and the ability to perform subgroup analyses of the health effects of air pollution on groups of disadvantaged persons. However, Medicare claims do not include extensive individual-level data on behavioral risk fac-

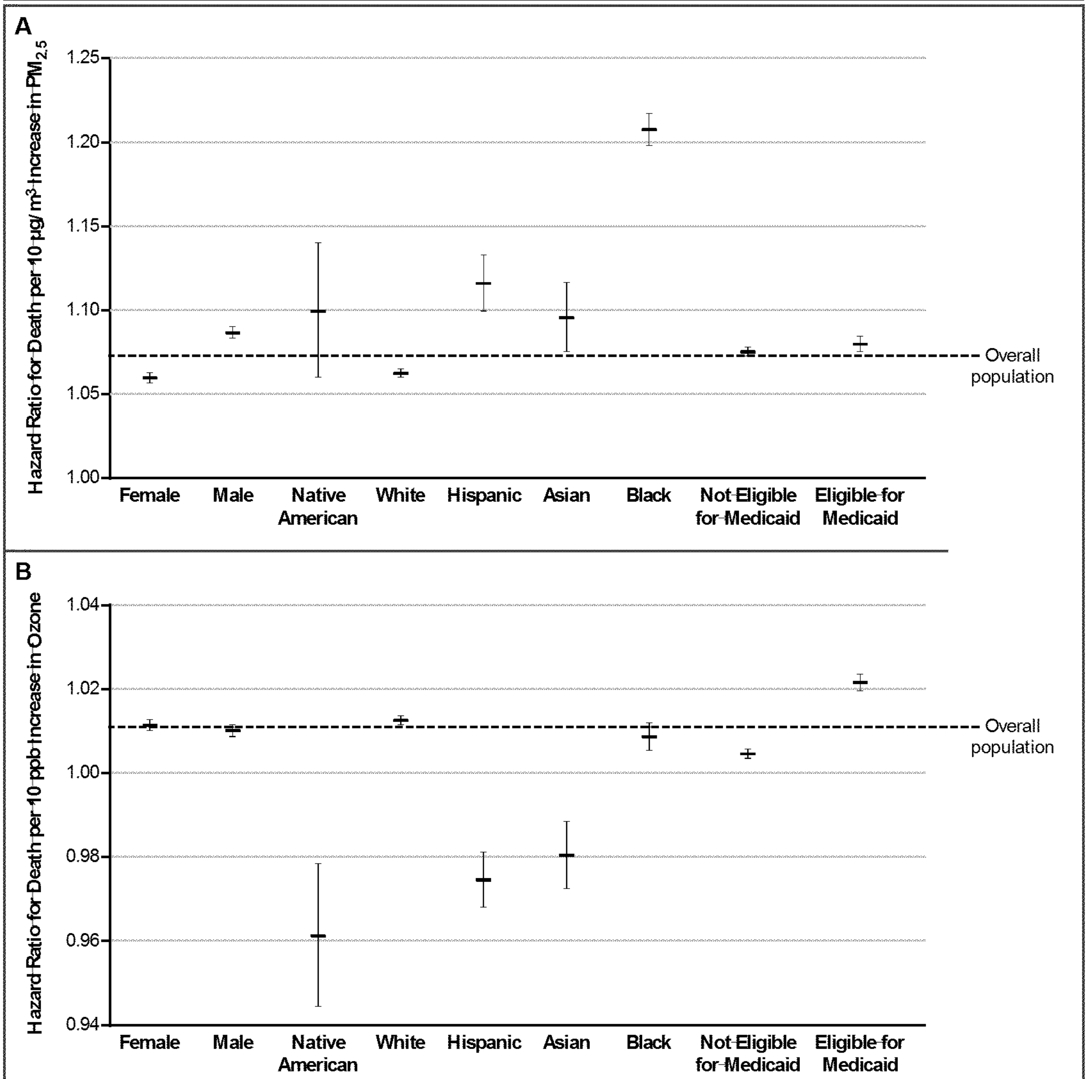

Figure 2. Risk of Death Associated with an Increase of 10 µg per Cubic Meter in $PM_{2.5}$ Concentrations and an Increase of 10 ppb in Ozone Exposure, According to Study Subgroups.

Hazard ratios and 95% confidence intervals are shown for an increase of 10 µg per cubic meter in $PM_{2.5}$ and an increase of 10 parts per billion (ppb) in ozone. Subgroup analyses were conducted by first restricting the population (e.g., considering only male enrollees). The same two-pollutant analysis (the main analysis) was then applied to each subgroup. Numeric results are presented in Tables S3 and S4 in the Supplementary Appendix. Dashed lines indicate the estimated hazard ratio for the overall population.

tors, such as smoking and income, which could be important confounders. Still, our analysis of the MCBS subsample (Table S6 in the Supplementary Appendix) increased our level of confidence that the inability to adjust for these individual-level risk factors in the Medicare cohort did not lead to biased results (Section 5 in the Supplementary Appendix). In another study, we analyzed a similar Medicare subsample with detailed individual-level data on smoking, BMI, and many other potential confounders linked to Medicare claims.[23] In that analysis, we found that for mortality and hospitalization, the risks of exposure to $PM_{2.5}$ were not sensitive to the additional control of individual-level variables that were not available in the whole Medicare population.

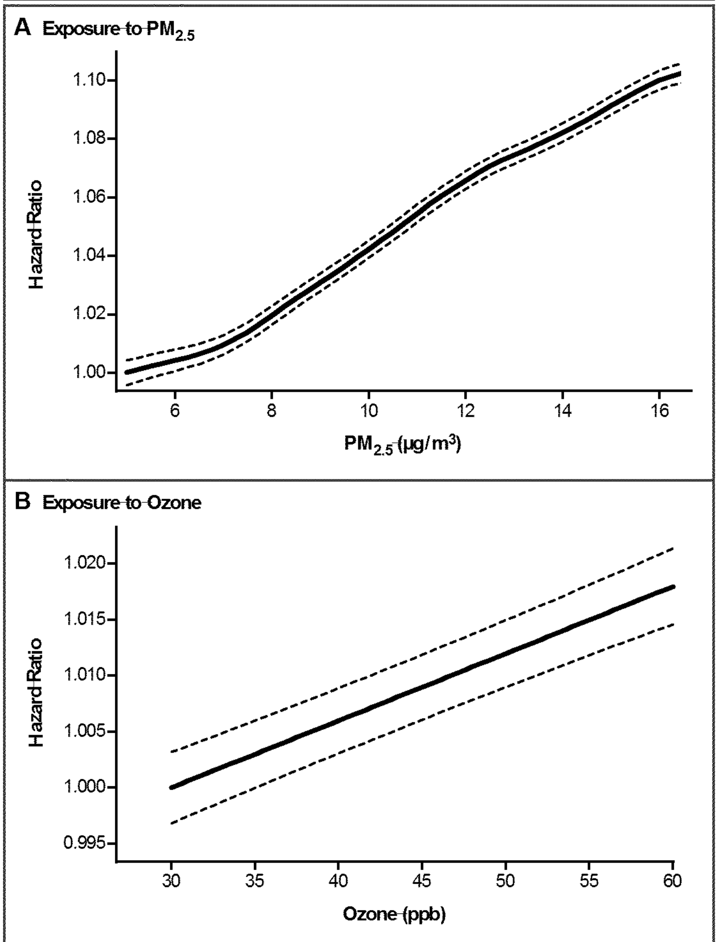

Figure 3. Concentration–Response Function of the Joint Effects of Exposure to $PM_{2.5}$ and Ozone on All-Cause Mortality.

A log-linear model with a thin-plate spline was fit for both $PM_{2.5}$ and ozone, and the shape of the concentration-response surface was estimated (Fig. S8 in the Supplementary Appendix). The concentration–response curve in Panel A was plotted for an ozone concentration equal to 45 ppb. The concentration–response curve in Panel B was plotted for a $PM_{2.5}$ concentration equal to 10 µg per cubic meter. These estimated curves were plotted at the 5th and 95th percentiles of the concentrations of $PM_{2.5}$ and ozone, respectively. The complete concentration–response three-dimensional surface is plotted in Fig. S8 in the Supplementary Appendix.

We also found that our results were robust when we excluded individual and ecologic covariates from the main analysis (Fig. S2 and Table S2 in the Supplementary Appendix), when we stratified age at entry into 3-year and 4-year categories rather than the 5 years used in the main analysis (Fig. S3 in the Supplementary Appendix), when we varied the estimation procedure (by means of a generalized estimating equation as opposed to mixed effects) (Tables S3 and S4 in the Supplementary Appendix), and when we used different types of statistical software (R, version 3.3.2, vs. SAS, version 9.4). Finally, we found that our results were consistent with others published in the literature (Section 6 in the Supplementary Appendix).[5,17,24-28]

There was a significant association between $PM_{2.5}$ exposure and mortality when the analysis was restricted to concentrations below 12 µg per cubic meter, with a steeper slope below that level. This association indicated that the health-benefit-per-unit decrease in the concentration of $PM_{2.5}$ is larger for $PM_{2.5}$ concentrations that are below the current annual NAAQS than the health benefit of decreases in $PM_{2.5}$ concentrations that are above that level. Similar, steeper concentration-response curves at low concentrations have been observed in previous studies.[29] Moreover, we found no evidence of a threshold value — the concentration at which $PM_{2.5}$ exposure does not affect mortality — at concentrations as low as approximately 5 µg per cubic meter (Fig. 3); this finding is similar to those of other studies.[18,30]

The current ozone standard for daily exposure is 70 ppb; there is no annual or seasonal standard. Our results strengthen the argument for establishing seasonal or annual standards. Moreover, whereas time-series studies have shown the short-term effects of ozone exposure, our results indicate that there are larger effect sizes for longer-term ozone exposure, including in locations where ozone concentrations never exceed 70 ppb. Unlike the American Cancer Society Cancer Prevention Study II,[9,10] our study reported a linear connection between ozone concentration and mortality. This finding is probably the result of the interaction between $PM_{2.5}$ and ozone (Section 7 in the Supplementary Appendix). The significant, linear relationship between seasonal ozone levels and all-cause mortality indicates that current risk assessments,[31-33] which incorporate only the acute effects of ozone exposure on deaths each day from respiratory mortality, may be substantially underestimating the contribution of ozone exposure to the total burden of disease.

The enormous sample size in this study, which includes the entire Medicare cohort, allowed for unprecedented accuracy in the estimation of risks among racial minorities and disadvantaged subgroups. The estimate of effect size for $PM_{2.5}$ exposure was greatest among male, black, and Medicaid-eligible persons. We also estimated risks in subgroups of persons who were eligible for Medicaid and in whites and blacks alone to ascertain whether the effect modifications according to race and Medicaid status were independent. We found that black persons who were not eligible for Medicaid (e.g., because of higher income) continued to have an increased risk of death from exposure to $PM_{2.5}$ (Fig. S4 in the Supplementary Appendix). In addition, we found that there was a difference in the health effects of $PM_{2.5}$ exposure between urban and rural populations, a finding that may be due to compositional differences in the particulates (Table S3 Supplementary Appendix).

Although the Medicare cohort includes only the population of persons 65 years of age or older, two thirds of all deaths in the United States occur in people in that age group. Although our exposure models had excellent out-of-sample predictive power on held-out monitors, they do have limitations. Error in exposure assessment remains an issue in this type of analysis and could attenuate effect estimates for air pollution.[34]

The overall association between air pollution and human health has been well documented since the publication of the landmark Harvard Six Cities Study in 1993.[25] With air pollution declining, it is critical to estimate the health effects of low levels of air pollution — below the current NAAQS — to determine whether these levels are adequate to minimize the risk of death. Since the Clean Air Act requires the EPA to set air-quality standards that protect sensitive populations, it is also important to focus more effort on estimating effect sizes in potentially sensitive populations in order to inform regulatory policy going forward.

The views expressed in this article are those of the authors and do not necessarily represent the official views of the funding agencies. Furthermore, these agencies do not endorse the purchase of any commercial products or services related to this publication.

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No potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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EDITORIALS

Air Pollution Still Kills

Rebecca E. Berger, M.D., Ramya Ramaswami, M.B., B.S., M.P.H., Caren G. Solomon, M.D., M.P.H., and Jeffrey M. Drazen, M.D.

In late October 1948, a dense smog descended over the town of Donora, Pennsylvania. The town was home to a zinc plant and a steel mill, both run by the United States Steel Corporation. Susan Gnora, a 62-year-old resident of Donora, started to gasp and cough as the smog descended.[1] She died the next day. Dr. William Rongaus, a physician and a member of the board of health, went door to door, treating patients for their respiratory symptoms and encouraging them to leave town if they could. Many thousands were ill, and at least 20 people died in one of the worst air-pollution disasters in U.S. history. The Donora tragedy transformed our perception of smog from a nuisance to a potential killer.

We started to improve air quality with the Clean Air Act of 1963. In 1970, Richard Nixon established the Environmental Protection Agency (EPA) by executive order, and the Clean Air Act was amended to institute National Ambient Air Quality Standards (NAAQS), which set exposure limits for six major air pollutants.[2] Among the pollutants regulated by the EPA is fine particulate matter — inhalable particles with an aerodynamic diameter of less than 2.5 μm ($PM_{2.5}$). Major contributors to $PM_{2.5}$ in the United States include various types of transportation and the coal-fired generation of electricity.[3,4] Since the 1970s, hundreds of articles have been written establishing an association between $PM_{2.5}$ and poor health outcomes, including asthma, ischemic heart disease, and all-cause mortality in urban populations.[5,6] In response to these findings, regulators have lowered NAAQS for the allowable amount of $PM_{2.5}$ in the air.[7] Current NAAQS, last updated in 2012, set an annual mean $PM_{2.5}$ level of 12 μg per cubic meter. This standard, which is to be reviewed every 5 years, aims to protect the population, especially those who are particularly sensitive to the adverse effects of air pollution, including children, elderly persons, and persons with cardiopulmonary disease.[2] As communities meet these stricter standards, fewer people will become sick and die as a result of air pollution. A 2011 report from the EPA projected that by 2020, amendments to the Clean Air Act would prevent more than 230,000 premature deaths, largely as a result of reductions in $PM_{2.5}$ levels.[8] But are current standards sufficient to protect public health?

Di et al. now report in the *Journal* the results of a large study, including more than 60 million Medicare beneficiaries from the years 2000 through 2012, that addresses the association between annual average levels of $PM_{2.5}$ and ozone,[9] as measured at the ZIP Code level, and mortality. For every increase of 10 μg per cubic meter in $PM_{2.5}$, there was an associated 7.3% increase in all-cause mortality (95% confidence interval [CI], 7.1 to 7.5), after adjustment for demographic characteristics, Medicaid eligibility, and area-level covariates. Below the current NAAQS for $PM_{2.5}$ of 12 μg per cubic meter, the data showed that each increase in $PM_{2.5}$ of 10 μg per cubic meter was associated with an even greater increase (13.6%) in mortality (95% CI, 13.1 to 14.1). There was no appreciable level below which the risk of death tapered off — and thus no "safe" level of $PM_{2.5}$. Owing to the large size of the cohort, Di et al. were able to perform robust sub-

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group analyses and identified greater risks of death associated with air pollutants among blacks and Medicaid-eligible populations; moreover, these groups were more likely to be exposed to higher pollutant levels.

The findings of Di et al. stress the need for tighter regulation of air-pollutant levels, including the imposition of stricter limits on levels of $PM_{2.5}$. Despite compelling data, the Trump administration is moving headlong in the opposite direction. In March, Trump signed an executive order that lifted a moratorium on new leases for coal mined on public and tribal lands and began a process to dismantle guidelines intended to reduce emissions from coal-fired electricity plants.[10] Earlier this month, he announced his intention to withdraw the United States from the Paris climate agreement. Although these actions were primarily intended to undo efforts made by the Obama administration to address climate change, the potentially dire consequences also include increasing people's exposure to particulate matter. In addition, EPA Administrator Scott Pruitt has not ruled out the possibility of revoking a waiver included in the 1970 Clean Air Act that allows California to set limits on automotive tailpipe emissions that are more stringent than national standards[11]; 15 states have adopted California's standards. Revoking this waiver could have the effect of exposing more than 100 million Americans to higher levels of automobile emissions. Trump's proposed budget includes crippling cuts to the EPA, including cuts in funding for both federal and state enforcement of regulations. The increased air pollution that would result from loosening current restrictions would have devastating effects on public health.

In explaining his withdrawal from the Paris climate agreement, Trump stated, "I was elected to represent the citizens of Pittsburgh, not Paris." Ironically, Pittsburgh is less than 30 miles from the Donora Smog Museum, where a sign reads, "Clean Air Started Here." With the report by Di et al. adding to the large body of evidence indicating the risks of air pollution, even at current standards, we must redouble our commitment to clean air. If such protections lapse, Americans will suffer and we are doomed to repeat history. Do we really want to breathe air that kills us?

Disclosure forms provided by the authors are available with the full text of this editorial at NEJM.org.

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Nationwide study of U.S. seniors strengthens link between air pollution and premature death

Key takeaways:

- *Study of 60 million U.S. senior citizens—about 97% of Americans 65+—shows long-term exposure to certain air pollutants increases the risk of premature death at levels below current national standards.*

- *12,000 lives could be saved annually by lowering levels of one of the pollutants, airborne fine particulate matter ($PM_{2.5}$), by 1 microgram per cubic meter.*

- *Men, blacks, and low-income populations had higher risks of premature death from $PM_{2.5}$ exposure, with blacks three times as likely to die prematurely.*

Embargoed for release: Wednesday, June 28, 2017, 5:00 PM ET

Boston, MA — A new study of 60 million Americans—about 97% of people age 65 and older in the United States—shows that long-term exposure to airborne fine particulate matter ($PM_{2.5}$) and ozone increases the risk of premature death, even when that exposure is at levels below the National Ambient Air Quality Standards (NAAQS) currently established by the U.S. Environmental Protection Agency.

The Harvard T.H. Chan School of Public Health researchers found that men, blacks, and low-income populations had higher risk estimates from $PM_{2.5}$ exposure compared with the national average, with blacks having mortality risks three times higher than the national average.

The results showed that if the level of $PM_{2.5}$ could be lowered by just 1 microgram per cubic meter ($\mu g/m^3$) nationwide, about 12,000 lives could be saved every year. Similarly, if the level of ozone could be lowered by just 1 part per billion (ppb) nationwide, about 1,900 lives would be saved each year.

The study will be published in the DATE issue of the *New England Journal of Medicine.*

“This is a study of unprecedented statistical power because of the massive size of the study population. These findings suggest that lowering the NAAQS for fine particulate matter will produce important public health benefits, especially among self-identified racial minorities and people with low incomes,” said Francesca Dominici, principal investigator of this study and professor of biostatistics at Harvard Chan School and co-director of the Harvard Data Science Initiative.

The researchers examined Medicare claims records of 60 million Americans 65+ over a seven-year period, representing 460 million person-years of follow-up. They also estimated air pollution levels at each 1 kilometer grid for the entire U.S. upon which the claims data could be overlaid and interpreted.

To do this, the Harvard Chan researchers leveraged the results of an exposure prediction model developed by doctoral student Qian Di, and Joel Schwartz, professor of environmental epidemiology and the study’s senior author. The exposure prediction model leverages satellite-based measurements and a computer simulation of air pollution.

By relying on this well-validated prediction model, the team was able to include subjects who live in unmonitored and less-populated areas so that the effects of air pollution on all 60 million people could be analyzed regardless of whether they lived in urban, suburban, or rural areas.

“This study shows that although we think air quality in the United States is good enough to protect our citizens, in fact we need to lower pollution levels even further,” said Schwartz.

Other Harvard Chan authors include Yan Wang, Antonella Zanobetti, Yun Wang, Petros Koutrakis, and Christine Choirat.

This study was made possible by the support from the NIH grant R01 ES024332-01A1, ES-000002, ES024012, R01ES026217; NIH/NCI grant R35CA197449; HEI grant 4953-RFA14-3/16-4, and USEPA grants

83587201-0, RD-83479801.

"Air Pollution and Mortality in the Entire Medicare Population," Qian Di, Yan Wang, Antonella Zanobetti, Yun Wang, Petros Koutrakis, Christine Choirat, Francesca Dominici, Joel D. Schwartz, *New England Journal of Medicine*, date, doi TK

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Harvard T.H. Chan School of Public Health brings together dedicated experts from many disciplines to educate new generations of global health leaders and produce powerful ideas that improve the lives and health of people everywhere. As a community of leading scientists, educators, and students, we work together to take innovative ideas from the laboratory to people's lives—not only making scientific breakthroughs, but also working to change individual behaviors, public policies, and health care practices. Each year, more than 400 faculty members at Harvard Chan School teach 1,000-plus full-time students from around the world and train thousands more through online and executive education courses. Founded in 1913 as the Harvard-MIT School of Health Officers, the School is recognized as America's oldest professional training program in public health.

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Wed 6/28/2017 5:30:11 PM
Subject: RE: Paper in New England Journal of Medicine

Francesca is the last author

I can send an email and copy you

Or you can email her directly

She has talked to John Vandenberg about

Let me know

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, June 28, 2017 12:59 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Paper in New England Journal of Medicine

I just heard that a paper is coming out from Harvard with the Medicare cohort. Any chance I can get a copy?

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Thur 6/1/2017 12:44:50 AM
Subject: RE: ACE Center Directors Call

Have you arrived?

If yes welcome

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, May 31, 2017 8:43 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Brent Coull <bacoull@gmail.com>
Subject: Re: ACE Center Directors Call

Ok.

See you in the morning.

Regards,

Sherri Hunt

571.339.9491

Sent from my iPhone

On May 31, 2017, at 6:16 PM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> Sherri I am looking forward seeing you tomorrow
>
> Regarding the fee we agree with you and decided not to bother
>
> Regarding the fifteen thousand dollars liability definitely it is not our fault
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However I will not agree to pay the entire amount and I am determined to fight it

I think my proposal is reasonable

See you tomorrow

Sent from my iPhone

> On May 30, 2017, at 9:14 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
>
> meals

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
Cc: Brent Coull[bacoull@gmail.com]
From: Koutrakis, Petros
Sent: Wed 5/31/2017 10:15:22 PM
Subject: Re: ACE Center Directors Call

Sherri I am looking forward seeing you tomorrow

Regarding the fee we agree with you and decided not to bother

Regarding the fifteen thousand dollars liability definitely it is not our fault
I have all emails showing that we came up with numbers based on their request

The best I can do it to participate I think this is a reasonable compromise

However I will not agree to pay the entire amount and I am determined to fight it

I think my proposal is reasonable

See you tomorrow

Sent from my iPhone

> On May 30, 2017, at 9:14 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
>
> meals

To: Brent Coull[bacoull@gmail.com]; Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Fri 5/26/2017 5:10:05 PM
Subject: RE: ACE Center Directors Call

Sheri I had to be forceful today because I do not want us to pay for the mistakes of others

Have a nice weekend

petros

From: Brent Coull [mailto:bacoull@gmail.com]
Sent: Friday, May 26, 2017 7:52 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Re: ACE Center Directors Call

Hi Sherri, I am happy to lead the discussion. Unfortunately I cannot make the call today but I'd love to hear your thoughts on what'd you'd like for that session. Would you like a report back from certain sessions? A summary of certain themes from the two days? Or should I serve more as a moderator for open discussion from the entire group?

Thanks

Brent

On May 26, 2017, at 7:38 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Let's discuss the final agenda and smaller group times.

Call Agenda for 5/26/17:

Logistics (Alice & Petros)

Meeting agenda (latest draft is attached):

finalize:

• Group discussion leaders (Schwartz not yet confirmed),

• final discussion (Coull not yet confirmed),

• anything else?

Apologies for the late reschedule.

<mime-attachment.ics>

<Agenda-ACE Annual Meeting 20170523.docx>

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Thur 4/27/2017 6:54:05 PM
Subject: RE: ACE Centers Annual Meeting

sure

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:47 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: ACE Centers Annual Meeting

I'll spend some time with it and circle back to you.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, April 27, 2017 2:44 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Centers Annual Meeting

These are nice guys

But I do not want to say something because they will disagree

I suggest you take over the agenda

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: ACE Centers Annual Meeting

Shoulder shrug…

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, April 27, 2017 2:25 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Centers Annual Meeting

I do not understand this negativity

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:05 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Bell, Michelle <michelle.bell@yale.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Baxter, Lisa <Baxter.Lisa@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Roger Peng <rdpeng@jhu.edu>
Subject: FW: ACE Centers Annual Meeting

Sherri

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Thur 4/27/2017 6:44:13 PM
Subject: RE: ACE Centers Annual Meeting

These are nice guys

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To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: ACE Centers Annual Meeting

Shoulder shrug…

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Sent: Thursday, April 27, 2017 2:25 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
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I do not understand this negativity

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Sent: Thursday, April 27, 2017 2:05 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Bell, Michelle <michelle.bell@yale.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Baxter, Lisa <Baxter.Lisa@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Roger Peng <rdpeng@jhu.edu>
Subject: FW: ACE Centers Annual Meeting

Sherri

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Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
From: Koutrakis, Petros
Sent: Sun 4/2/2017 5:58:56 AM
Subject: Re: Letter to the Editor on our PNAS article

Great Sherri
Please keep it confidential for now

See you in a month

Petros

Sent from my iPhone

On Apr 2, 2017, at 2:40 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Thank you, Petros. When you learn the publication date, please let us know.

Yes – I plan to attend the HEI meeting – it's practically in my back yard. ☺ I hope that we can catch up.

All the best,

Sherri

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, March 27, 2017 11:37 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Subject: FW: Letter to the Editor on our PNAS article

FYI, confidential

Are you going to HEI meeting, if yes I am looking forward seeing you there

From: Baccarelli, Andrea [mailto:ab4303@cumc.columbia.edu]
Sent: Monday, March 27, 2017 10:19 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Diane Gold <redrg@channing.harvard.edu>; Jia Zhong <jiazhong@mail.harvard.edu>
Subject: Letter to the Editor on our PNAS article

Hi Petros,

We received a letter sent by Lucock et al to the PNAS editor that is critical of our article.

We prepared (I need to say that Diane did most of the work) a response that is attached here.

Due to the sensitivity of the issue discussed, we would appreciate your review of our response. I am attaching the PDFs of our published article as well as of the letter submitted by Lucock et al.

Andrea

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 6/1/2017 11:23:49 AM
Subject: RE: ACE Center Directors Call

Yes. ☺

But I turned off my computer for the night.

Sherri

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, May 31, 2017 8:45 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Center Directors Call

Have you arrived?

If yes welcome

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, May 31, 2017 8:43 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Cc: Brent Coull <bacoull@gmail.com>
Subject: Re: ACE Center Directors Call

Ok.

See you in the morning.

Regards,

Sherri Hunt

571.339.9491

Sent from my iPhone

On May 31, 2017, at 6:16 PM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> Sherri I am looking forward seeing you tomorrow
>
> Regarding the fee we agree with you and decided not to bother
>
> Regarding the fifteen thousand dollars liability definitely it is not our fault
> I have all emails showing that we came up with numbers based on their request
>
> The best I can do it to participate I think this is a reasonable compromise
>
> However I will not agree to pay the entire amount and I am determined to fight it
>
> I think my proposal is reasonable
>
> See you tomorrow
>
> Sent from my iPhone
>
>> On May 30, 2017, at 9:14 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
>>
>> meals

To: Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Bell, Michelle[michelle.bell@yale.edu]; Jones, Diana[diana.jones@yale.edu]; Roger Peng[rdpeng@jhu.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]
Cc: Petros Koutrakis[Petros@hsph.harvard.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 5/4/2017 4:29:45 PM
Subject: Reminder: Rooms for ACE Centers Meeting June 1-2

Hi All,

This is a reminder that Alice (asmythe@hsph.harvard.edu) needs to know details for hotel rooms (numbers, names, and dates if not 5/31/17 – 6/2/17) for the meeting. If you are not included in the room block, it may be difficult to get a room nearby.

Please contact Alice as soon as possible with the needs of your team.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Brent Coull[bacoull@gmail.com]
From: Hunt, Sherri
Sent: Thur 6/1/2017 12:42:35 AM
Subject: Re: ACE Center Directors Call

Ok.

See you in the morning.

Regards,
Sherri Hunt
571.339.9491

Sent from my iPhone

On May 31, 2017, at 6:16 PM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> Sherri I am looking forward seeing you tomorrow
>
> Regarding the fee we agree with you and decided not to bother
>
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> See you tomorrow
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> Sent from my iPhone
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> > On May 30, 2017, at 9:14 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
> >
> > meals

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 5/2/2017 6:13:16 PM
Subject: Re: Hei

:)

I'll let you know my schedule soon.

Regards,
Sherri Hunt
571.339.9491

Sent from my iPhone

On May 2, 2017, at 9:42 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> I know you have many responsibilities
>
> I am in Boston
>
> I have some important meetings and I had to leave
>
> If you have time to go for dinner when you come to Boston I will be happy to go out with you and other epa folks if they wish
>
> **From:** Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
> **Sent:** Tuesday, May 2, 2017 9:34 AM
> **To:** Koutrakis, Petros <petros@hsph.harvard.edu>
> **Cc:** Smythe, Alice <asmythe@hsph.harvard.edu>
> **Subject:** Re: Hei
>
> Same. It's always hard for local meetings and small kids.
>
> Are you leaving? I'll be here all day.
>
> Regards,

Sherri Hunt

571.339.9491

Sent from my iPhone

On May 2, 2017, at 9:31 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> Sherri it was nice seeing you sorry we did not have the chance to chat much
>
> The invitation was sent to HEI
>
> **From:** Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
> **Sent:** Monday, May 1, 2017 11:50 AM
> **To:** Koutrakis, Petros <petros@hsph.harvard.edu>
> **Subject:** Re: Hei
>
> You can.
>
> No preference.
>
> Regards,
>
> Sherri Hunt
>
> 571.339.9491
>
> Sent from my iPhone
>
> On May 1, 2017, at 11:39 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:
>
> > Great do you want to invite them?
> > Or do you want me to ask them
> >
> > I am if they do not give a presentation

Sent from my iPhone

On May 1, 2017, at 11:19 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

To attend - definitely.

To speak - maybe. I'll check.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

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Washington DC 20004

-----Original Message-----

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, May 01, 2017 10:28 AM

To: Hunt, Sherri <Hunt.Sherri@epa.gov>

Subject: Hei

Can we invite hei to the annual meeting?

It is a shame because they are local.

Sent from my iPhone

To: Koutrakis, Petros[petros@hsph.harvard.edu]; Brent Coull[bacoull@gmail.com]
Bcc: Ilacqua, Vito[Ilacqua.Vito@epa.gov]; Callan, Richard[Callan.Richard@epa.gov]; Keating, Terry[Keating.Terry@epa.gov]
From: Hunt, Sherri
Sent: Tue 5/30/2017 1:14:15 PM
Subject: RE: ACE Center Directors Call

Hi Petros,

I understand this is a challenging situation. I've spent more time thinking about this and also reviewed the Centers T&C.

The T&C for your award states that each Center will host one annual Centers meeting. While I'm happy to plan times for discussion and to participate in the development of the meeting agenda, it's problematic for me (or others in my office) to contribute to discussions regarding the financial aspects of the meeting because this gives the appears that EPA is directing a grantee in how funds are spent. Consequently, it would be best for you to resolve this issue without my involvement.

On a related note, several months ago I informed EPA meeting employees that they should expect to pay a fee to cover meals if they want to participate in the group meals and breaks. NCER management has determined that calling this a registration fee (as we did in the past) is no longer acceptable. However, I don't recall whether this issue was ever discussed on a directors' call and I haven't been able to find anything regarding this in my notes. Since formally, the T&C don't specify it means to "host," this is something that you should clarify with the other Centers. If this has not been discussed, then I would anticipate that the other Centers are not expecting to pay a fee. (My personal feeling during the CLARCs was that this ended up being a lot of work to pass funds between institutions for a result that probably did not change the balance at the end of the projects.)

Finally, the goal of these meetings is to improve the connections and collaborations across Centers. This is important as it has been one of the strong points for justifying the importance and value of the Centers program. From this perspective, you should consider the other Center investigators in the same way that you would any scientific visitor to Harvard.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Sent: Friday, May 26, 2017 1:10 PM
To: Brent Coull <bacoull@gmail.com>; Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Center Directors Call

Sheri I had to be forceful today because I do not want us to pay for the mistakes of others

Have a nice weekend

petros

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Thanks

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Let's discuss the final agenda and smaller group times.

Call Agenda for 5/26/17:

Logistics (Alice & Petros)

Meeting agenda (latest draft is attached):

finalize:

•□□□□□□□□ Group discussion leaders (Schwartz not yet confirmed),

•□□□□□□□□ final discussion (Coull not yet confirmed),

•□□□□□□□□ anything else?

Apologies for the late reschedule.

<mime-attachment.ics>

<Agenda-ACE Annual Meeting 20170523.docx>

To: Koutrakis, Petros[petros@hsph.harvard.edu]
Cc: Alice Smythe[asmythe@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 5/2/2017 1:34:05 PM
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Same. It's always hard for local meetings and small kids.

Are you leaving? I'll be here all day.

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Sent from my iPhone

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You can.

No preference.

Regards,

Sherri Hunt

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To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Mon 5/1/2017 3:50:07 PM
Subject: Re: Hei

You can.

No preference.

Regards,
Sherri Hunt
571.339.9491

Sent from my iPhone

On May 1, 2017, at 11:39 AM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

> Great do you want to invite them?
> Or do you want me to ask them
>
> I am if they do not give a presentation
>
> Sent from my iPhone
>
>> On May 1, 2017, at 11:19 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
>>
>> To attend - definitely.
>>
>> To speak - maybe. I'll check.
>>
>> Sherri
>>
>> ---
>>
>> Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
>>
>> National Center for Environmental Research | US Environmental Protection Agency
>>
>> 202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov
>>
>> Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R)

Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K)
Washington DC 20004

-----Original Message-----

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]

Sent: Monday, May 01, 2017 10:28 AM

To: Hunt, Sherri <Hunt.Sherri@epa.gov>

Subject: Hei

Can we invite hei to the annual meeting?

It is a shame because they are local.

Sent from my iPhone

To: Brent Coull[bacoull@gmail.com]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Fri 5/26/2017 12:35:10 PM
Subject: RE: ACE Center Directors Call

Thanks, Brent. I was thinking of something like a moderator – but I'm open to anything that might be valuable.

In my head, I imagined each center director/co-director commenting about any valuable points from the meeting and then some discussion about connections, and directions. It might be good to prepare a couple of leading questions to help the group digest the whole meeting and pull things together. I feel like these kinds of conversations often happen following a meeting in the lobby or on the way to the airport. My hope was to get the larger group involved.

I'll let you know what the others think after the call.

Make sense?

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Brent Coull [mailto:bacoull@gmail.com]
Sent: Friday, May 26, 2017 7:52 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>

Subject: Re: ACE Center Directors Call

Hi Sherri, I am happy to lead the discussion. Unfortunately I cannot make the call today but I'd love to hear your thoughts on what'd you'd like for that session. Would you like a report back from certain sessions? A summary of certain themes from the two days? Or should I serve more as a moderator for open discussion from the entire group?

Thanks

Brent

On May 26, 2017, at 7:38 AM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

> Let's discuss the final agenda and smaller group times.
>
> **Call Agenda for 5/26/17:**
>
> Logistics (Alice & Petros)
>
> Meeting agenda (latest draft is attached):
>
> finalize:
>
> •□□□□□□□□ Group discussion leaders (Schwartz not yet confirmed),
>
> •□□□□□□□□ final discussion (Coull not yet confirmed),
>
> •□□□□□□□□ anything else?
>
> Apologies for the late reschedule.
>
> <mime-attachment.ics>
>
> <Agenda-ACE Annual Meeting 20170523.docx>

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Mon 5/1/2017 3:19:04 PM
Subject: RE: Hei

To attend - definitely.

To speak - maybe. I'll check.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
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202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov
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-----Original Message-----
From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Monday, May 01, 2017 10:28 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Hei

Can we invite hei to the annual meeting?
It is a shame because they are local.

Sent from my iPhone

Air Climate Energy (ACE) Centers Meeting
Hosted by Harvard/MIT ACE Center
June 1 – 2, 2017
Le Meridien Hotel, 20 Sidney Street, Cambridge, MA

Thursday June 1, 2017		
8:30 AM	9:00 AM	Breakfast
9:00 AM	9:15 AM	Welcome: Petros Koutrakis, Dan Costa
9:15 AM	10:15 AM	CASES: Center for Air, Climate, and Energy Solutions
10:15 AM	10:45 AM	**Break**
10:45 AM	11:45 AM	SEARCH: Solutions to Energy, AiR, Climate and Health
11:45 AM	12:30 PM	EPA Related Activities: Life Cycle Assessment for Regionalization and Inventory Generation: Michael Gonzalez Including Social Science in Air Pollution Research: Lisa Baxter Perspective on needs within EPA Regions: Bob Judge
12:30 PM	2:00 PM	**Lunch**
2:00 PM	3:00 PM	RAPM: Regional Air Pollution Mixtures: The past and future impacts of emissions controls and climate change on air quality and health, Harvard
3:00 PM	4:00 PM	**Collaborative Project Brainstorming** or **Data and Model Sharing** Optional groups: 1) Epidemiology of Long-term effects: Joel Schwartz 2) Sensors: Kirsten Koehler 3) Modeling tools and applications: Chris Tessum and Noelle Selin 4) Policy/stakeholder interaction: Julian Marshall 5) Others?
4:00 PM	4:30 PM	**Break**
4:30 PM	6:30 PM	Poster Session (max size 3' by 4', portrait or landscape)
6:30 PM	8:30 PM	Reception
8:30 PM		**Adjourn for the Day**
Friday June 2, 2017		
8:30 AM	9:00 AM	Breakfast
9:00 AM	9:30 AM	Insights on EJ Metrics: Julian Marshall
9:30 AM	10:00 AM	Insights from Policy Core: Michelle Bell
10:00 AM	10:30 AM	Insights on Reduced Form Models: Peter Adams
10:30 AM	11:00 AM	**Break**
11:00 AM	12:00 PM	Collaborative Project Brainstorming or Individual Center Time
12:00 PM	1:00 PM	Discussion: (Brent Coull) - Closing Thoughts (10 min per Center) - Other Comments or Discussion
1:00 PM		**Adjourn**

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 4/27/2017 6:47:20 PM
Subject: RE: ACE Centers Annual Meeting

I'll spend some time with it and circle back to you.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, April 27, 2017 2:44 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Centers Annual Meeting

These are nice guys

But I do not want to say something because they will disagree

I suggest you take over the agenda

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:27 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: ACE Centers Annual Meeting

Shoulder shrug…

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Thursday, April 27, 2017 2:25 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Centers Annual Meeting

I do not understand this negativity

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:05 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Bell, Michelle <michelle.bell@yale.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Baxter, Lisa <Baxter.Lisa@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Roger Peng <rdpeng@jhu.edu>
Subject: FW: ACE Centers Annual Meeting

Sherri

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From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 4/27/2017 6:27:04 PM
Subject: RE: ACE Centers Annual Meeting

Shoulder shrug…

Sherri

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To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: ACE Centers Annual Meeting

I do not understand this negativity

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, April 27, 2017 2:05 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>; Bell, Michelle <michelle.bell@yale.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Jones, Diana <diana.jones@yale.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Baxter, Lisa <Baxter.Lisa@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Roger Peng <rdpeng@jhu.edu>

Subject: FW: ACE Centers Annual Meeting

Sherri

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From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 4/26/2017 7:56:35 PM
Subject: RE: ACE Centers Annual Meeting

Great – thank you.

Sherri

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Sent: Wednesday, April 26, 2017 3:55 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: ACE Centers Annual Meeting

Hi Sherri, still a draft but attached is the latest which can be used for tomorrow's call.

Thanks

Alice

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 4/26/2017 6:32:50 PM
Subject: RE: ACE Centers Annual Meeting

OK – thanks.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 1:45 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: ACE Centers Annual Meeting

No it is ok to ask her

She is on line but I just wanted to let you know why was not around

Looking forward seeing soon

Sent from my iPhone

On Apr 26, 2017, at 1:41 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Oh no!

I’m so sorry to hear about this. Alice feels like family to me and I’m sure this feeling is even stronger for you.

I’ll hold any other questions that come up. I only seem to have a draft agenda.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, April 26, 2017 1:29 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: ACE Centers Annual Meeting

Hi Sherri

Alice has been battling with cancer

She had two clots in the lungs and stayed at the hospital for eight days

She was out yesterday and is starting to take care of her emails

I thought we finalized the agenda

We are set but the only big issue is room vacancy

We will need to talk tomorrow

Sent from my iPhone

On Apr 26, 2017, at 1:24 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Hi Petros and Alice,

We are scheduled to have a Center Directors' call tomorrow afternoon. Can you please let me know if you feel ready for the annual meeting or whether there are issues to discuss? Also, do we have a final agenda? (Several EPA folks have asked me for this.)

Thanks,

Sherri

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To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Mon 5/15/2017 11:17:10 AM
Subject: Re: ACE Centers Meeting, agenda suggestions

Thanks.

Regards,
Sherri Hunt
571.339.9491

Sent from my iPhone

On May 14, 2017, at 8:55 PM, Koutrakis, Petros <petros@hsph.harvard.edu> wrote:

This looks fine to me see you soon

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Thursday, May 11, 2017 3:14 PM
To: Bell, Michelle <michelle.bell@yale.edu>; Jones, Diana <diana.jones@yale.edu>; Koutrakis, Petros <petros@hsph.harvard.edu>; Smythe, Alice <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; Julian Marshall <jdmarsh@uw.edu>; Katherine Tucker <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <Ilacqua.Vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <Costa.Dan@epa.gov>
Subject: RE: ACE Centers Meeting, agenda suggestions

Hi All,

This is a reminder to have a look at the agenda. So far the only feedback I've received has been from Alice regarding logistics. Lots of EPA people are asking about this.

I'd especially like to know if Julien and Michelle are okay with the additional topics that I assigned to them.

Thanks for your quick response!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Hunt, Sherri
Sent: Friday, May 05, 2017 12:28 PM
To: 'Bell, Michelle' <michelle.bell@yale.edu>; 'Jones, Diana' <diana.jones@yale.edu>; Petros Koutrakis <Petros@hsph.harvard.edu>; Alice Smythe <asmythe@hsph.harvard.edu>; Allen Robinson <alr@andrew.cmu.edu>; 'Julian Marshall' <jdmarsh@uw.edu>; 'Katherine Tucker' <tuckerk@andrew.cmu.edu>
Cc: Ilacqua, Vito <ilacqua.vito@epa.gov>; Callan, Richard <Callan.Richard@epa.gov>; Keating, Terry <Keating.Terry@epa.gov>; Costa, Dan <costa.dan@epa.gov>
Subject: ACE Centers Meeting, agenda suggestions

Hi All,

Based on the discussion at our last directors call, I've developed the attached revised the meeting agenda. Please provide feedback to the items below and anything else to me as soon as possible. Let's make a hard deadline of next Friday, May 12.

A couple of items are worth specific note:

(in no particular order, some logistical and some content)

1. I kept Center presentation times at 60 minutes, but allocated a shorter time for EPA updates. Is everyone ok with this?

2. I decided to give the Harvard Center the acronym RAPM (pronounced rap-em). This can be rejected without consequences.

3. Do we want to include speaker names on the agenda? I expect each Center may have multiple speakers. I'm happy to do whatever, but suggest consistency so if we are including names, I need to know what they are.

4. The Collaborative Project Brainstorming/Discussion groups are simply suggestions. I think it makes sense to have people from the Centers lead these since most successful projects have a champion working on them. If we are going to do this, I need your feedback on the topics and the leaders. NCER and EPA will be happy to participate in the discussion and support with notetaking.

5. I kept the hour between the poster session and reception, but is it needed?

6. Are we already committed to a start time for the reception on June 1?

7. On June 2, I likely need corrections to the speakers for the morning talks. Also, is this a good grouping? Any changes to suggest?

8. June 2 also includes a block of time which could be for more collaborative discussions or for meetings within each Center (since two of them are geographically dispersed). Which do you prefer?

9. We should identify a closing discussion leader and some key questions on points to be made. Suggestions?

Thanks a bunch.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 4/26/2017 5:41:11 PM
Subject: RE: ACE Centers Annual Meeting

Oh no!

I'm so sorry to hear about this. Alice feels like family to me and I'm sure this feeling is even stronger for you.

I'll hold any other questions that come up. I only seem to have a draft agenda.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Sent: Wednesday, April 26, 2017 1:29 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: ACE Centers Annual Meeting

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She had two clots in the lungs and stayed at the hospital for eight days

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>
> Thanks,
>
> Sherri
>
> ---
>
> Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
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> Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460
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> Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Petros Koutrakis[Petros@hsph.harvard.edu]; Alice Smythe[asmythe@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 4/26/2017 5:24:54 PM
Subject: ACE Centers Annual Meeting

Hi Petros and Alice,

We are scheduled to have a Center Directors' call tomorrow afternoon. Can you please let me know if you feel ready for the annual meeting or whether there are issues to discuss? Also, do we have a final agenda? (Several EPA folks have asked me for this.)

Thanks,

Sherri

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To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Mon 5/8/2017 2:23:19 PM
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Thanks, Alice.

I'll bug around EPA again a bit.

I think people are not accustomed to room blocks with hard commitments – I agree this is very frustrating and resulting in taking up too much of our time.

(I can always try to help with the hotel – you can certainly refer to very real budget uncertainty.)

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, May 08, 2017 10:19 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Hi, it’s 25 but EPA is only 2 away from fulfilling 80% of the government rate room block which is good. If 2 more sign up we’ll be looking good.

We are quite put out by the fact that the CMU group told us that their estimate could go as high as 35 – so I put them down for 25 to be safe but I got an email on Friday from Kate saying that only about 8 are going. Anyway, I will try like heck to sweet talk the hotel into forgiving some of our commitment but it’s a legal contract and they may not go for it. This is the first time we’ve ever had this problem.

Hi Alice,

I have heard from 20 people that they are likely to attend. We have not heard back from 15 people, so our headcount could be as high as 35. I estimate that we’ll end up with 20 – 30 CACES representatives. I hope this is helpful!

Thank you,

Kate

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Monday, May 08, 2017 10:03 AM
To: Smythe, Alice
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Thanks, Alice. What was our commitment for rooms?

Have you been getting needed info from other Centers?

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, May 08, 2017 8:26 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: FW: New guest Michael Gonzalez for GOVT rate room block

Sherri, latest EPA annual meeting hotel rooming list.

Thanks

Alice

From: Fabrina Pena-Guzman [mailto:fabrina.guzman@lemeridiencambridge.com]
Sent: Friday, May 05, 2017 12:43 PM
To: Smythe, Alice
Subject: RE: New guest Michael Gonzalez for GOVT rate room block

Hi Alice,

Please find attached the updated rooming list with all your additions from yesterday.

Let me know if you have any questions. Have a wonderful weekend!

My best,

Fabrina Peña-Guzman

Conference Services Manager
T +1 617 551 0312   F +1 617 551 0444

fabrina.guzman@lemeridiencambridge.com

N 42°21' W 71°6'

LE MERIDIEN
CAMBRIDGE - MIT

20 Sidney Street, Cambridge, MA 02139 USA

lemeridien.com/cambridge

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]

Sent: Thursday, May 04, 2017 12:58 PM
To: Fabrina Pena-Guzman
Subject: New guest Michael Gonzalez for GOVT rate room block

Hi Fabrina,

Please add Michael Gonzalez to the government rate room block for 2 nights – checking in May 31, checking out June 2.

Thank you very much,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

https://sites.sph.harvard.edu/ace/

This email has been scanned by the Symantec Email Security.cloud service.
For more information please visit http://www.symanteccloud.com

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]; Ilacqua, Vito[ilacqua.vito@epa.gov]
From: Hunt, Sherri
Sent: Mon 3/13/2017 11:08:52 PM
Subject: RE: Science Advisory Committee invitation

Great! I'm certain that his modeling expertise will be helpful.

Thanks.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, March 13, 2017 5:35 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Fwd: Science Advisory Committee invitation

Hi Sherri,

S.T. Rao has accepted our invitation to serve on our ACE Center SAC.

Thanks

Alice

Sent from my Virgin Mobile Phone.

-------- Original message --------

From: "S.T. Rao" <strao@ncsu.edu>

Date: 3/13/2017 4:21 PM (GMT-05:00)

To: "Smythe, Alice" <asmythe@hsph.harvard.edu>

Cc: "Koutrakis, Petros" <petros@hsph.harvard.edu>

Subject: Re: Science Advisory Committee invitation

Hello Alice and Petros,

Thanks for the invitation to be on your SAC. Yes, I'll plan on attending your meeting In mid May. Please send me the agenda and project information so I can be prepared for your meeting.

Regards,

ST

Sent from my iPad

S.T. Rao, Ph.D.

Editor-in-Chief, Journal of the Air & Waste Management Association

Google Scholar: https://scholar.google.com/citations?user=ngHmbQIAAAAJ&hl=en

Adjunct Professor, Department of Marine, Earth, and Atmospheric Sciences

North Carolina State University, Raleigh, NC 27695

E-mail: strao@ncsu.edu

and

Adjunct Professor, Department of Civil & Environmental Engineering

University of Connecticut, Storrs, CT 06269

E-mail: s.t.rao@uconn.edu

On Mar 13, 2017, at 3:47 PM, Smythe, Alice <asmythe@hsph.harvard.edu> wrote:

Dear Dr. Rao:

Petros asked me to contact you to invite you to serve as a committee member on the Science Advisory Committee of the USEPA Air, Climate and Energy Center (ACE). If you accept we also hope you will be available to participate in the SAC meeting which takes place in Boston on May 16 and 17. We apologize for not having issued this invitation sooner and for the short notice but we hope you will say yes to both joining the committee and to the meeting.

Thank you,

Alice

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

https://content.sph.harvard.edu/ace/

To: Smythe, Alice[asmythe@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 2/21/2017 3:29:01 PM
Subject: RE: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Hi Alice,

It's always uncertain when inviting speakers at that level. I'd suggest planning for her, but having a couple of ideas for back-ups who are people you know might be available or willing to fill in at the last minute. It's worth taking a chance since she would certainly be interesting.

You could suggest that a response be given by April 15 or May 1.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Monday, February 20, 2017 4:05 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: FW: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Hi Sherri and Vito,

We have formally invited Gina McCarthy to give the keynote talk at the Centers Annual Meeting June 1. Her response is below. Please advise us on whether you think we take the risk of penciling her into the agenda or if we rule her out since she doesn't seem able to commit at the moment, despite otherwise being willing. Petros is keen to have her but we'd like to have your input.

Thanks

Alice

From: McCarthy, Gina [mailto:Gina_McCarthy@hks.harvard.edu]
Sent: Friday, February 17, 2017 5:17 PM
To: Smythe, Alice
Subject: RE: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Alice – thank you for inviting me. I would be honored to do this but I am not sure at this point what the future may bring for me so it's hard to make a firm commitment. When do you need a know for sure? Can we talk then?

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Friday, February 17, 2017 3:11 PM
To: McCarthy, Gina <Gina_McCarthy@hks.harvard.edu>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Invitation to give keynote talk at ACE Centers Annual Meeting, June 1 2017

Dear Dr. McCarthy,

I am contacting you at the request of Dr. Petros Koutrakis, Director of the Harvard/MIT Air, Climate & Energy (ACE) Center and Professor of Environmental Sciences at HSPH.

The annual ACE Centers meeting will take place on June 1 and 2 of 2017 in Cambridge, MA. As former EPA Administrator, the directors of the ACE centers would be very interested and honored, if you are available, to have you give the keynote address during lunch on June 1 to meeting attendees.

Please would you mind letting me know if you are available to do this on June 1, 2017.

Thank you very much,

Alice Smythe (Assistant to Petros Koutrakis)

Alice Smythe

Exposure, Epidemiology & Risk Program

Harvard T. H. Chan School of Public Health

Landmark Center West, Room 410-a

401 Park Drive

Boston, MA 02215

Tel: +1-617-384-8831

Fax: +1-617-384-8833

http://www.hsph.harvard.edu/clarc

To: Smythe, Alice[asmythe@hsph.harvard.edu]
Cc: Koutrakis, Petros[petros@hsph.harvard.edu]; Ilacqua, Vito[Ilacqua.Vito@epa.gov]
From: Hunt, Sherri
Sent: Wed 2/1/2017 8:20:11 PM
Subject: RE: Another SAC Recommendation

Right – thanks for the reminder. I'll get to that later today.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Smythe, Alice [mailto:asmythe@hsph.harvard.edu]
Sent: Wednesday, February 01, 2017 3:01 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Cc: Koutrakis, Petros <petros@hsph.harvard.edu>; Ilacqua, Vito <Ilacqua.Vito@epa.gov>
Subject: RE: Another SAC Recommendation

Hi Sherri,

I will send him a formal invitation.

You'll recall you had managed to secure rooms in Boston for EPA folks at the government rate using a Federal employee site that I don't have access to. If possible, would you mind adding him?

Thank you!

Alice

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, February 01, 2017 2:46 PM
To: Smythe, Alice
Cc: Koutrakis, Petros; Ilacqua, Vito
Subject: Another SAC Recommendation

Hi Alice,

As Petros and I just discussed, here is the information for Scott Jenkins for invitation to the SAC meeting. Scott has formal training in Neurology and he is current acting as a science advisor in the Health and Environmental Effects Division of OAQPS. He will be helpful in commenting on how the work of the Center relates to the most current policy issues.

Jenkins.scott@Epa.gov

919-541-1167

Please let me know if you have any trouble contacting him.

Thanks very much to both of you.

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 1/31/2017 2:30:50 PM
Subject: RE: Quick question

Yes – please.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Tuesday, January 31, 2017 9:19 AM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: Quick question

Sure I will call

I can call now before 10 if you wish

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Tuesday, January 31, 2017 9:13 AM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Quick question

Hi Petros,

I have a quick question for you. I'm scheduled to be in meetings today from 10 am to 4 pm, but available later. Please give me a call if you have time late this afternoon or tomorrow.
571.339.9491 (cell)

Thanks.

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Petros Koutrakis[Petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Tue 1/31/2017 2:13:19 PM
Subject: Quick question

Hi Petros,

I have a quick question for you. I'm scheduled to be in meetings today from 10 am to 4 pm, but available later. Please give me a call if you have time late this afternoon or tomorrow.
571.339.9491 (cell)

Thanks.

Sherri

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Hunt, Sherri[Hunt.Sherri@epa.gov]
Cc: Day, Melissa[Day.Melissa@epa.gov]
Bcc: jbaumgartner@umn.edu[jbaumgartner@umn.edu]; petera@andrew.cmu.edu[petera@andrew.cmu.edu]; carlton@envsci.rutgers.edu[carlton@envsci.rutgers.edu]; krksmith@berkeley.edu[krksmith@berkeley.edu]; jhkroll@mit.edu[jhkroll@mit.edu]; daven.henze@colorado.edu[daven.henze@colorado.edu]; pgh25@cornell.edu[pgh25@cornell.edu]; kdemerjian@albany.edu[kdemerjian@albany.edu]; Kuo-Jen.Liao@tamuk.edu[Kuo-Jen.Liao@tamuk.edu]; odman@gatech.edu[odman@gatech.edu]; nenes@eas.gatech.edu[nenes@eas.gatech.edu]; yark@uiuc.edu[yark@uiuc.edu]; ptolber@sph.emory.edu[ptolber@sph.emory.edu]; John.Volckens@ColoState.edu[John.Volckens@ColoState.edu]; chen@seas.wustl.edu[chen@seas.wustl.edu]; edwardsr@uci.edu[edwardsr@uci.edu]; michelle.bell@yale.edu[michelle.bell@yale.edu]; akua@engr.ucr.edu[akua@engr.ucr.edu]; jjschauer@wisc.edu[jjschauer@wisc.edu]; andrey.khlystov@dri.edu[andrey.khlystov@dri.edu]; petros@hsph.harvard.edu[petros@hsph.harvard.edu]; alr@andrew.cmu.edu[alr@andrew.cmu.edu]; ng@chbe.gatech.edu[ng@chbe.gatech.edu]; svedal@u.washington.edu[svedal@u.washington.edu]; jeff.hatten@oregonstate.edu[jeff.hatten@oregonstate.edu]; rjstev@cns.msu.edu[rjstev@cns.msu.edu]; surratt@unc.edu[surratt@unc.edu]; ddabdub@uci.edu[ddabdub@uci.edu]; evf@atmos.colostate.edu[evf@atmos.colostate.edu]; Jose.Jimenez@Colorado.edu[Jose.Jimenez@Colorado.edu]; mjkleeman@ucdavis.edu[mjkleeman@ucdavis.edu]; blamb@wsu.edu[blamb@wsu.edu]; xliang@umd.edu[xliang@umd.edu]; yang.liu@emory.edu[yang.liu@emory.edu]; ljm@io.harvard.edu[ljm@io.harvard.edu]; shane.murphy@uwyo.edu[shane.murphy@uwyo.edu]; rowangould@unm.edu[rowangould@unm.edu]; ted.russell@ce.gatech.edu[ted.russell@ce.gatech.edu]; rodney.weber@eas.gatech.edu[rodney.weber@eas.gatech.edu]; harkemaj@msu.edu[harkemaj@msu.edu]; petros@hsph.harvard.edu[petros@hsph.harvard.edu]; Rob.Bailis@sei-us.org[Rob.Bailis@sei-us.org]; yark@uiuc.edu[yark@uiuc.edu]; lmrussell@ucsd.edu[lmrussell@ucsd.edu]; betsy-stone@uiowa.edu[betsy-stone@uiowa.edu]; hannigan@colorado.edu[hannigan@colorado.edu]; slwu@mtu.edu[slwu@mtu.edu]; af2544@columbia.edu[af2544@columbia.edu]
From: Hunt, Sherri
Sent: Mon 1/9/2017 8:01:10 PM
Subject: FYI: Emissions Inventory Conference August 14-18, 2017, in Baltimore, MD

Hi All,

The Emissions Inventory and Analysis Group, in EPA's Office of Air Quality Planning and Standards, is pleased to announce the dates for the 2017 Emissions Inventory Conference (EIC). Please mark your calendars for August 14-18, 2017, in Baltimore, MD. Additional information on the conference venue will be provided in the near future, so stay tuned. The Abstracts are due no later than Friday, February 17, 2017.

The EIC brings together offices across EPA that work on various aspects of emissions inventory development. The theme for the 2017 EIC is "Applying Science and Streamlining Processes to Improve Inventories." As in years past, we expect to offer 1.5 days of training, followed by an engaging plenary session with numerous technical sessions that will cover a wide range of science and policy topics related to emissions inventories. We also anticipate panel and breakout discussions on specific aspects of inventories.

(Apologies to those uninterested.)

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Dominici, Francesca[fdominic@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 6/29/2017 5:41:44 PM
Subject: RE: NEJM paper?

Nope - sorry.

Meant to respond to a friend who requested a copy.

:]

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface
National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov
Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460
Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

-----Original Message-----
From: Dominici, Francesca [mailto:fdominic@hsph.harvard.edu]
Sent: Thursday, June 29, 2017 12:29 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: NEJM paper?

Did you want send this to me ?

> On Jun 29, 2017, at 12:08 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:
>
> Hi Greg,
>
> Paper is attached along with the editorial accompanying it. Enjoy!
>
> Regards,
> Sherri
> ____
> _ Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix
> Interface National Center for Environmental Research | US
> Environmental Protection Agency
>
> 202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov<mailto:hunt.sherri@epa.gov>
> Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460
> Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004
>
> From: Dominici, Francesca [mailto:fdominic@hsph.harvard.edu]
> Sent: Wednesday, June 28, 2017 2:43 PM
> To: Hunt, Sherri <Hunt.Sherri@epa.gov>
> Subject: Re: NEJM paper?
>
> here is it + HSPH press release
> the NEJM editorial is powerful
> just keep in mind that this is embargoed until 5 pm today we are
> getting a lot of press attention
>
>

> FRANCESCA DOMINICI, PHD |
> co-Director of the Harvard Data Science Initiative Professor of
> Biostatistics | Department of Biostatistics Harvard T.H. Chan School
> of Public Health
> 677 Huntington Avenue, 4-th Floor, Room 441, Building 2 | Boston, MA
> 02115
> o: 617-432-4908| c: 410-258-5886 | f:617-432-5619
> fdominic@hsph.harvard.edu<mailto:fdominic@hsph.harvard.edu>
> http://www.hsph.harvard.edu/francesca-dominici/
>
> For appointments and scheduling please contact Joan Elizabeth Whalen
> Email: jwhalen@hsph.harvard.edu<mailto:jwhalen@hsph.harvard.edu>
>
>
>
> On Jun 28, 2017, at 2:35 PM, Hunt, Sherri <Hunt.Sherri@epa.gov<mailto:Hunt.Sherri@epa.gov>> wrote:
>
> Hi Francesca,
>
> I heard about your paper during an HEI call today. It sounds like people are quite excited. I'm wondering whether you can send a copy – I'll like to write something for our communications team to add to the note that goes out on Friday.
>
> (I do understand if you want to wait until tomorrow though.)
>
> Regards,
> Sherri
> ____
> _ Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix
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> Environmental Protection Agency
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> Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460
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>
> <17062906.pdf>
> <17062915.pdf>

To: Dominici, Francesca[fdominic@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Thur 6/29/2017 4:08:50 PM
Subject: RE: NEJM paper?
17062906.pdf
17062915.pdf

Hi Greg,

Paper is attached along with the editorial accompanying it. Enjoy!

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

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Sent: Wednesday, June 28, 2017 2:43 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: NEJM paper?

here is it + HSPH press release

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just keep in mind that this is embargoed until 5 pm today

we are getting a lot of press attention

FRANCESCA DOMINICI, PHD |

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Harvard T.H. Chan School of Public Health
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fdominic@hsph.harvard.edu
http://www.hsph.harvard.edu/francesca-dominici/

For appointments and scheduling please contact
Joan Elizabeth Whalen
Email: jwhalen@hsph.harvard.edu

On Jun 28, 2017, at 2:35 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

Hi Francesca,

I heard about your paper during an HEI call today. It sounds like people are quite excited. I'm wondering whether you can send a copy – I'll like to write something for our communications team to add to the note that goes out on Friday.

(I do understand if you want to wait until tomorrow though.)

Regards,

Sherri

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Dominici, Francesca[fdominic@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 6/28/2017 6:45:55 PM
Subject: RE: NEJM paper?

Thank you!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

National Center for Environmental Research | US Environmental Protection Agency

202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

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To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: Re: NEJM paper?

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FRANCESCA DOMINICI, PHD |

co-Director of the Harvard Data Science Initiative
Professor of Biostatistics | Department of Biostatistics
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fdominic@hsph.harvard.edu
http://www.hsph.harvard.edu/francesca-dominici/

For appointments and scheduling please contact
Joan Elizabeth Whalen
Email: jwhalen@hsph.harvard.edu

On Jun 28, 2017, at 2:35 PM, Hunt, Sherri <Hunt.Sherri@epa.gov> wrote:

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(I do understand if you want to wait until tomorrow though.)

Regards,

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: fdominic@hsph.harvard.edu[fdominic@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 6/28/2017 6:35:27 PM
Subject: NEJM paper?

Hi Francesca,

I heard about your paper during an HEI call today. It sounds like people are quite excited. I'm wondering whether you can send a copy – I'll like to write something for our communications team to add to the note that goes out on Friday.

(I do understand if you want to wait until tomorrow though.)

Regards,

Sherri

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Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 6/28/2017 6:33:35 PM
Subject: RE: Paper in New England Journal of Medicine

OK – sure. Thanks!

Sherri

Sherri W. Hunt, Ph.D. | Air, Climate, and Energy (ACE) Matrix Interface

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202.564.4486 (office) | 571.339.9491 (cell) | hunt.sherri@epa.gov

Mailing Address: 1200 Pennsylvania Ave NW (Code 8725R) Washington DC 20460

Courier Address: 1300 Pennsylvania Ave NW (RRB Mezzanine M312K) Washington DC 20004

From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, June 28, 2017 2:28 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: Paper in New England Journal of Medicine

Sherri I spoke to Francesca and she told me if you do not mind to email her asking the paper

I guess she wants to communicate directly with you

Dominici, Francesca (fdominic@hsph.harvard.edu)

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, June 28, 2017 2:08 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: RE: Paper in New England Journal of Medicine

Can you send please?

My guess is that she sent it to Vito – but he's on vacation.

Sherri

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From: Koutrakis, Petros [mailto:petros@hsph.harvard.edu]
Sent: Wednesday, June 28, 2017 1:30 PM
To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: Paper in New England Journal of Medicine

Francesca is the last author

I can send an email and copy you

Or you can email her directly

She has talked to John Vandenberg about

Let me know

From: Hunt, Sherri [mailto:Hunt.Sherri@epa.gov]
Sent: Wednesday, June 28, 2017 12:59 PM
To: Koutrakis, Petros <petros@hsph.harvard.edu>
Subject: Paper in New England Journal of Medicine

I just heard that a paper is coming out from Harvard with the Medicare cohort. Any chance I can get a copy?

Sherri

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To: Koutrakis, Petros[petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 6/28/2017 6:08:01 PM
Subject: RE: Paper in New England Journal of Medicine

Can you send please?

My guess is that she sent it to Vito – but he's on vacation.

Sherri

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To: Hunt, Sherri <Hunt.Sherri@epa.gov>
Subject: RE: Paper in New England Journal of Medicine

Francesca is the last author

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Sent: Wednesday, June 28, 2017 12:59 PM
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Subject: Paper in New England Journal of Medicine

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Sherri

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To: Petros Koutrakis[Petros@hsph.harvard.edu]
From: Hunt, Sherri
Sent: Wed 6/28/2017 4:59:03 PM
Subject: Paper in New England Journal of Medicine

I just heard that a paper is coming out from Harvard with the Medicare cohort. Any chance I can get a copy?

Sherri

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To: Ilacqua, Vito[ilacqua.vito@epa.gov]; Callan, Richard (Callan.Richard@epa.gov)[/o=ExchangeLabs/ou=Exchange Administrative Group (FYDIBOHF23SPDLT)/cn=Recipients/cn=7e7e051eb3e74f3eac0876cab7e3eb16-callan, richard]; Katz, Taylor[Katz.Taylor@epa.gov]; Costa, Dan[costa.dan@epa.gov]; Alan Vette (Vette.Alan@epa.gov)[Vette.Alan@epa.gov]; Miller, Andy[Miller.Andy@epa.gov]; Hassett-Sipple, Beth[Hassett-Sipple.Beth@epa.gov]; Bell, Michelle[michelle.bell@yale.edu]; Roger Peng[rdpeng@jhu.edu]; Petros Koutrakis[Petros@hsph.harvard.edu]; bcoull@hsph.harvard.edu[bcoull@hsph.harvard.edu]; Allen Robinson[alr@andrew.cmu.edu]; Julian Marshall[jdmarsh@uw.edu]; Katherine Tucker[tuckerk@andrew.cmu.edu]; Alice Smythe[asmythe@hsph.harvard.edu]; Jones, Diana[diana.jones@yale.edu]
Cc: Baxter, Lisa[Baxter.Lisa@epa.gov]; Grambsch, Anne[Grambsch.Anne@epa.gov]; Hagler, Gayle[Hagler.Gayle@epa.gov]; Nunez, Carlos[Nunez.Carlos@epa.gov]
From: Hunt, Sherri
Sent: Mon 6/19/2017 5:23:31 PM
Subject: ACE Center Directors Call

Hi All,

I am unable to attend an ACE Center Directors call this Thursday due to parenting responsibilities. However, I would like to have a discussion to follow-up on items discussed at our recent meeting and other coordination and collaborations. I'm deleting this calendar entry, but Rich Callan will be polling the group and scheduling a new meeting time. Rich will be taking over the coordination of these calls.

Regards,

Sherri

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